ASBESTOS – CEMENT
PRESSURE PIPES
AND LOW PRESSURE PIPES

ITALIT

[illegible]

THIS BOOK HAS BEEN *compiled and written for the purpose of providing information to Public Authorities, Engineers and Architects who are concerned with the conveyance of fluids for civil and industrial applications. Attention is directed to the technical experimental data and graphs, showing the many advantages of the comparatively new material Asbestos-cement in comparison with older materials employed for conduit purposes.*

ITALIT

ASBESTOS-CEMENT PRESSURE PIPES

FOR WATER AND OTHER FLUIDS UNDER PRESSURE

•

LOW PRESSURE PIPES

FOR SEWER, WASTE & SURFACE WATERS

IRRIGATION PIPES

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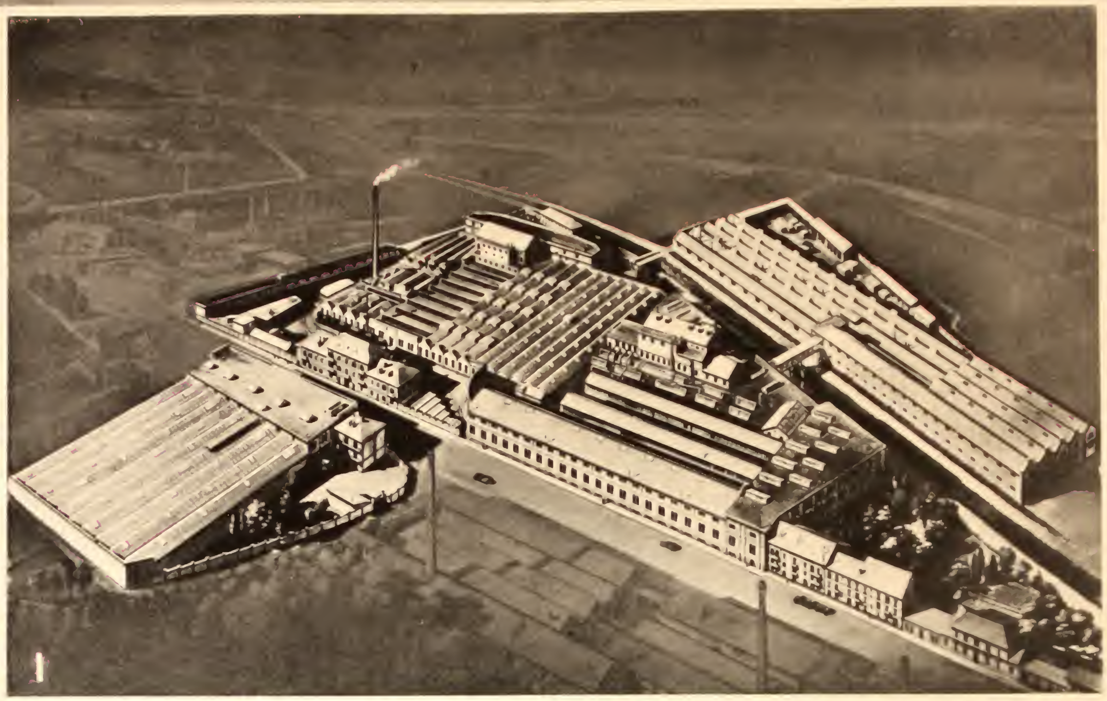
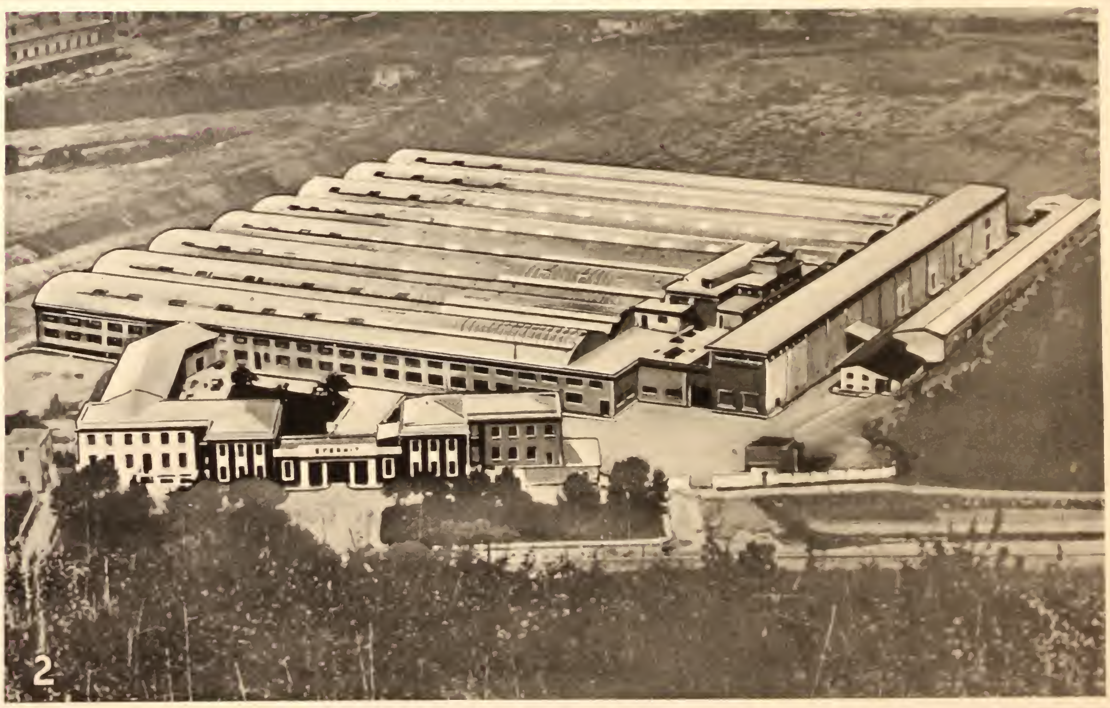
TWO OF THE PLANTS WHERE "ITALIT" ASBESTOS-CEMENT PIPES ARE MANUFACTURED





1. AERIAL VIEW OF THE WORKS AT CASALE MONFERRATO (PIEDMONT)
2. VIEW OF THE WORKS AT BAGNOLI (NAPLES)

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SOME IMPORTANT USERS OF "ITALIT" ASBESTOS-CEMENT PIPES

DRINKING WATER

BRITISH COLONIES etc.

CROWN AGENTS FOR THE COLONIES, LONDON

Tanganyika, Nigeria, Gold Coast, Sierra Leone, West Indies, Fed. Malay States, Sarawak.

AUSTRALIA

Brisbane City Council.

Queensland State Board Stores, Brisbane.

Shire Councils of:
Mount Morgan, Murilla and Sarina (Queensland)

Housing and Works Dept., Sydney.

Wangaratta Waterworks Trust, Melbourne.

Melbourne Board of Works.

Longreach Shire Council (Victoria).

ITALY

Italian Ministries of Communications and Public Works, Rome.

Acquedotto Consorziale del Monferrato, Turin.

Ente Autonomo Acquedotto Pugliese, Bari.

All the Largest Italian Municipalities.

LIBYA

Government of Tripoli.

GREECE

Greek Ministries of Agriculture and Reconstruction, Athens.

BULGARIA

Bulgarian Ministry of Public Works, Sofia.

SIAM

Government of Siam, Bankok.

CUBA

Government of Cuba, Havana.

ARGENTINA

Province of Buenos Aires Waterworks.

OIL AND ITS DERIVATIVES

PERSIA

Anglo-Persian Oil Company, Abadan.

U. S. INDONESIA

Bataafshe Industrie en Handel Miy, Sourabaya.

PERSIAN GULF

California Standard Oil Company, Bahrein.

ITALY

Società Nafta (Shell Group), Genoa.

Arsenals of the Italian Navy, La Spezia, Taranto.

TRIESTE

Standard Oil Company.

GAS

ITALY

Società Toscana Aziende Gas, Florence.

Società Italiana per il Gas, Rome.

Società Italgas, Turin.

Aziende Municipalizzate Gas & Acqua di:
Genoa, La Spezia, Biella, Apuania, Massa.

TRIESTE

Società Alti Forni della Venezia Giulia.

FRANCE

Societé du Gas de Paris, Paris.

continued

SOME IMPORTANT USERS OF "ITALIT" ASBESTOS-CEMENT PIPES

continued

SEA, INDUSTRIAL AND WASTE WATERS

ITALY

Municipality of Genoa
(*Municipal sea-water aqueduct for fire-fighting and street cleaning*).

Snia Viscosa, Turin (*Rayon manufacturers*).

Società Montecatini, Milan
(*Mining and Chemical Industries*).

Royal Hot Springs of Montecatini
(*Thermal Waters*).

FRANCE

Cartonnerie & Papeterie Feluziennes Felny Arquennes (*Paper Mills*).

SWEDEN

Oskarstrom Sulphite Mills, Oskarstrom
(*Cellulose Industries*).

U.S. INDONESIA

Shell Petroleum Company, Balik Papan
(*Chemical Industries*).

CUBA

Compania Rayonera Cubana, Havana
(*Chemical Industries*).

BRAZIL

Tiuma Sugar Company, Pernambuco
(*Sugar Refiners*).

ARGENTINA

Celuloso Argentina, Rosario de Santa Fé
(*Cellulose Industries*).

SEWAGE

TANGANYIKA

Dar-es-Salaam (*Main Drainage*).

ITALY

Municipalities of :

Perugia, San Remo, Sesto San Giovanni (Milan), Mondovi, Bordighera, Etc.

CABLE DUCTS

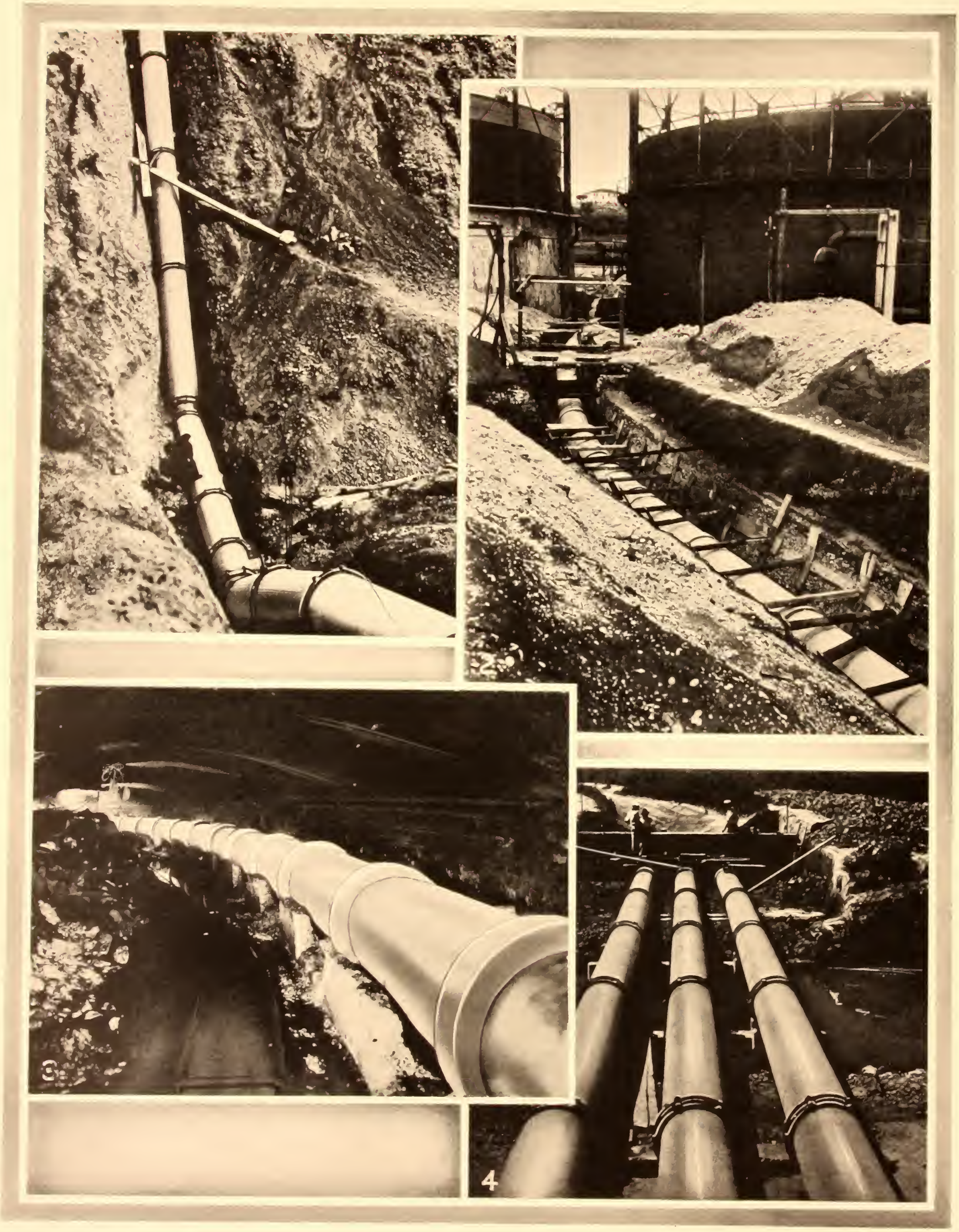
AUSTRALIA

Postmaster General Department, Melbourne.

ITALY

The Telephone State Companies of all major Italian towns.

VARIOUS USES OF "ITALIT" ASBESTOS-CEMENT PIPES



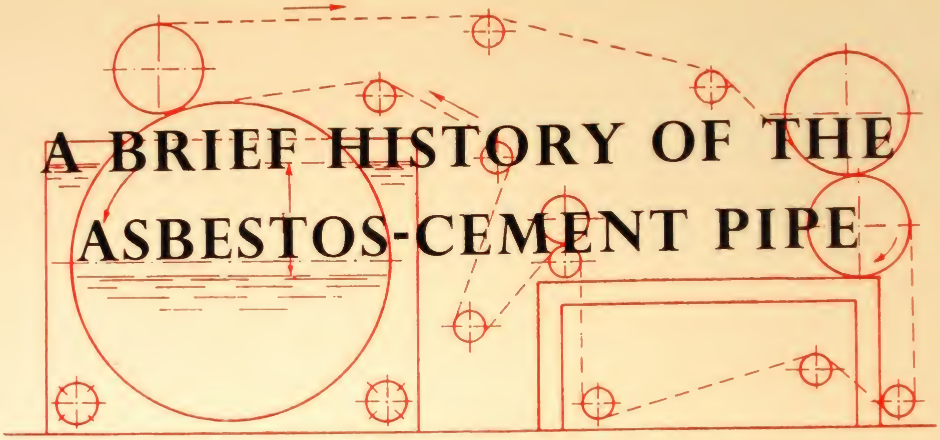
1. 24 IN. (600 MM.) DIA. PIPE-LINE WITH GIBAULT JOINT EMPLOYED IN HYDRO-ELECTRIC SCHEME

2. 40 IN. (1000 MM.) DIA. "ITALIT" PIPES WITH SIMPLEX JOINT FOR INDUSTRIAL WATERS INSTALLED BY A LARGE INDUSTRIAL CONCERN AT TERNI (ITALY)

3. 24 IN. (600 MM.) DIA. PIPES WITH SIMPLEX JOINT LAID IN A TUNNEL FOR A THERMO-ELECTRIC PLANT AT ANCONA

4. 20 IN. (500 MM.) DIA. PIPES EMPLOYED IN LAND RECLAMATION SCHEME NEAR FERRARA (ITALY)

A BRIEF HISTORY OF THE ASBESTOS-CEMENT PIPE



1907 Dr. A. Mazza, the President of Eternit Pietra Artificiale S.P.A. of Genoa, established a factory at Casale Monferrato, North Italy, to produce Asbestos-cement roofing materials under the process invented by L. Hatschek with whom he had earlier, collaborated in Austria.

1911 Dr. Mazza started experimenting in the manufacture of Asbestos-cement pipes for the conveyance of fluids under pressure. Two years later he took the first letters of patent on the manufacturing process invented by him.

1916 Production of the Asbestos-cement pipe under the Eternit-Mazza process began on a commercial basis.

1921 Patents were taken out by the Eternit Pietra Artificiale Company in the principal countries of the world and the following trade names were adopted:—

'ETERNIT' for Italian supplies.

'ITALIT' for supplies sent to other countries.

1923 After 12 years of constant study and experiment new patents on a manufacturing process obtaining a uniform compression along the whole of the pipe length were taken.

1925 Eighty-seven miles of 'Italit' pressure pipes were laid.

1948 Asbestos-cement mains made under the Eternit-Mazza process for a total length equalling two and a half times the circumference of the world were in use.

Seventeen countries, including the U.S.A., Great Britain, France and Germany were manufacturing pipes, under the Eternit-Mazza process.

FIG. I.—DR. ING. A. MAZZA, INVENTOR OF THE ASBESTOS-CEMENT PIPE, PRESIDENT OF ETERNIT S.P.A., GENOA

MANUFACTURE OF "ITALIT" ASBESTOS-CEMENT PIPES

"ITALIT" asbestos-cement pipes are manufactured from an intimate mixture of :—

(1) **ASBESTOS FIBRE** of high grade specially selected, disintegrated and inspected to ensure quality and uniformity.

These fibres, being finer than silk and flexible, are ideally suitable as a reinforcing agent in cement, for their high tensile strength and other physical properties.

(2) **PORTLAND CEMENT** having a compressive strength of 7,100 lb./sq. in. produced at the Works to a strict specification.

An emulsion of asbestos fibre, cement and water is conveyed to a vat provided with a hollow rotating cylinder, sheathed with fine copper gauze. A thin uniform layer of asbestos fibre and cement adheres to the sheath and excess water is drawn off by a regulated suction. The asbestos fibres lie flat, pointing in all directions, thus ensuring the great tensile strength of the resulting product. An endless belt of felt now takes the film, approximately 1/100 in. thick, of asbestos-cement; this passes over an oiled polished steel mandrel onto

FIG. 2.—PAN MIXING MACHINES FOR MIXING ASBESTOS FIBRE AND CEMENT IN WATER

FIG. 3.—THE RAW MATERIALS FROM WHICH ASBESTOS-CEMENT PIPES ARE MADE

which the asbestos-cement film is continuously transferred in the form of a spiral until the required thickness is built up; simultaneously a uniform pressure is exerted on the mandrel to ensure a homogenous,

compact, impermeable product, capable of withstanding pressure. It is worthy of note that throughout the manufacture of the pipes the process is exact, continuous, and fully visible. The pipes thus formed, are withdrawn from the mandrel and placed on a wooden former to set for 48 hours.

They are then placed in vats of water

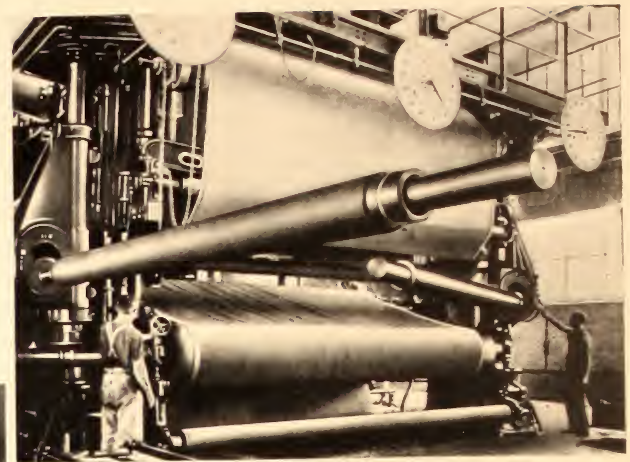


FIG. 4.—A MODERN MAZZA MACHINE FOR PRODUCING ~~PIPES IN 5 METRES LENGTHS.~~ LARGE DIAMETER PIPES

for one week, after which they are stored in special drying-sheds for at least 30 days to mature, the slow drying process giving greater strength.

Finally, they are trimmed to the correct length and the ends machined to ensure correct fitting of the joints.

FIG. 5.—VATS IN WHICH "ITALIT" PIPES UNDERGO THEIR INITIAL MATURING PROCESS SUBMERGED IN WATER.

Pipes are then hydraulically tested up to their guaranteed Test pressure.

" ITALIT " pipes, resulting from the above process are :—

(*a*) Homogenous, dense in structure and free from imperceptible flaws and weakness such as blow holes and sand.

(*b*) Waterproof.

(*c*) Perfectly cylindrical and uniform in thickness.

(*d*) Internally smooth and glossy, giving high, permanent carrying capacity.

(*e*) Durable ; a " life," on all present evidence, much longer than that of any other form of conduit.

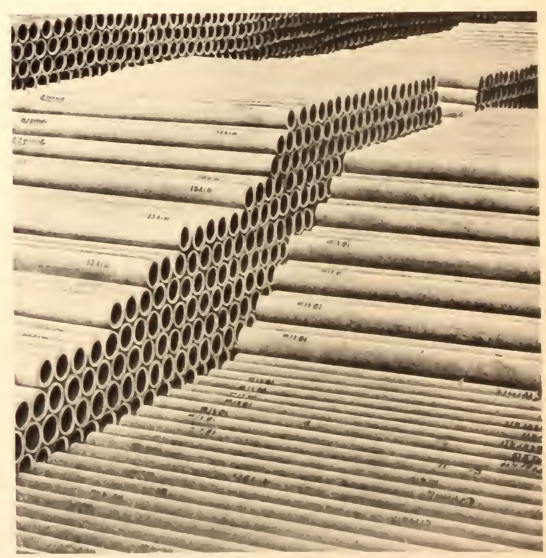


FIG. 6.—PIPES READY FOR DESPATCH.

TABLE I

FOR CONVERSION OF METRIC PIPE SIZES TO BRITISH MEASURES

METRIC DIMENSION *mm.*	BRITISH EQUIVALENT *ins.*	BRITISH NOMINAL *ins.*	METRIC DIMENSION *mm.*	BRITISH EQUIVALENT *ins.*	BRITISH NOMINAL *ins.*	METRIC DIMENSION *mm.*	BRITISH EQUIVALENT *ins.*	BRITISH NOMINAL *ins.*
25	·98	1	100	3·94	4	350	13·78	14
32	1·26	1¼	125	4·92	5	400	15·75	16
40	1·57	1½	150	5·91	6	450	17·72	18
50	1·97	2	175	6·89	7	500	19·69	20
60	2·36	2½	200	7·87	8	600	23·62	24
70	2·76	3	225	8·86	9	700	27·56	28
80	3·15	3¼	250	9·84	10	800	31·50	32
90	3·54	3½	300	11·81	12	900	35·43	36
						1000	39·37	40

1 metre = 1,000 mm. = 39·37 ins. = 3·28 ft.
1 inch = 25·40 mm.
1 foot = 0·3048 m.

1 kg./sq. cm. (metric atmosphere) = 14·2234 lb./sq. in.
1 lb./sq. in. = 0·070307 kg./sq. cm.
100 feet head of water = 43·35 lb./sq. in. = 3·048 kg./sq. cm.

FIG. 7.—PART OF A LARGE CONSIGNMENT OF BITUMINIZED PIPES FOR DAR-ES-SALAAM SEWERAGE SCHEME.

1. 16, 12 AND 5 INS. (400, 300, 125 MM.) DIA. PRESSURE PIPES WITH SIMPLEX JOINT EMPLOYED IN THE FOLIGNO ACQUEDUCT (CENTRAL ITALY)

2. SEWERAGE PIPE-LINE 12 IN. (300 MM.) DIA. CARRIED OUT IN "ITALIT" AT MARTINAFRANCA (ITALY). NOTE CONSIDERABLE DEPTH, APPROX. 20 FEET AT THIS POINT

TYPES & BRIEF CLASSIFICATION OF "ITALIT" PIPES

" ITALIT " *pipes are made in six types as briefly described below*

(1) " ITALIT " PRESSURE PIPES are used for water supply and distribution mains, pressure sewers, fire, brine and oil pipe lines and for many types of process pipe-lines in the paper, sugar and other industries. They are manufactured in six classes as follows :—

TABLE II

		CLASS A	CLASS B	CLASS C	CLASS D	CLASS E	CLASS F
Test Pressure at Works	ft. head	200	400	600	800	1,200	1,600
	lb./in.^{2}	86·7	173·4	260·1	346·8	520·2	693·6
(metric atmospheres)	kg./cm.^{2}	6·1	12·2	18·3	24·4	36·6	48·8
Range of diameters manufactured ...		1–40 ins.	1–40 ins.	1–40 ins.	1–24 ins.	1–12 ins.	1–12 ins.

The maximum hydrostatic pressure to which the pipes will be subjected in service, or that greater dynamic pressure which may occur due to certain known working conditions, *should not exceed one half of the above Test Pressures.*

" ITALIT " pressure pipes are manufactured in lengths of :—

2 m. = (6 ft. $6\frac{3}{4}$ ins.) = 2.187 yds. (804 pipes per mile)
3 m. = (9 ft. $10\frac{1}{8}$ ins.) = 3.281 yds. (536 pipes per mile)
4 m. = (13 ft. $1\frac{1}{2}$ ins.) = 4.375 yds. (402 pipes per mile)
5 m. = (16 ft. $4\frac{7}{8}$ ins.) = 5.468 yds. (322 pipes per mile)

Full specifications of these pipes and relative joints are given from page 19 to 73

(1a) " ITALIT " SPECIAL GAS PIPES. The same guarantee of gas-tightness current for cast iron are given for these pipes. They can be used for gas distribution mains, and are manufactured in the same diameters, as the pressure pipes.

(2) "ITALIT" LOW PRESSURE PIPES are used for gravity sewers, soil and drain pipes and cable ducts. They are made in one class only, tested at the following hydraulic pressures :—

DIAMETER in.	up to 10	12	14	16	18-20
FEET HEAD	66	56	53	50	46

Range of diameters up to 20 ins. as for the pressure pipes. Low pressure pipes are supplied with applied cup-type sockets or with separate joints. The joint is usually made with tarred rope and cement mortar or with bituminous mastic.

A full range of special pieces for these pipes is available.

Details of these pipes and relative fittings are given from page 75 to page 82.

(2a) "ITALIT" CABLE DUCTS as carriers for telephone, telegraph, and electric cables. For this purpose "ITALIT" low pressure pipes with socketed or plain ends are used.

For plain ended pipes the joint is made with an asbestos-cement sleeve and two rubber rings.

(3) "ITALIT" IRRIGATION PIPES. Used for irrigation of agricultural land. Made in one class only, tested at 100 ft. head hydraulic pressure, recommended for working pressures up to 50 ft. head.

Range of diameters : from 2 ins. to 12 ins.

Standard lengths : 1, 2, 3 m. (= 3.28 ft., 6.56 ft., 9.84 ft.).

These pipes are supplied with a monolithic socket at one end, and the joint is simply made with one rubber ring.

Special pieces and half-round channels for use in connection with irrigation pipes are available.

Details of these pipes and relative fittings, are given from page 83 to page 85.

(4) "ITALIT" VENTILATION AND SMOKE PIPES are used for industrial and domestic air and smoke ducts, exhaust and blower systems. They are made in circular and square cross sections in sizes from 2 ins. to 20 ins., and lengths up to 3 m. (9.84 ft.). Special pieces for these are also available.

Free translation of Extracts from

REPORT ON ASBESTOS-CEMENT (ETERNIT-ITALIT) CONDUITS INSPECTED AFTER MANY YEARS OF SERVICE

By Prof. Ing. Ettore SCIMEMI,

Principal of the Institute of Hydraulics, Padua University

THIS paper relates to a comprehensive survey on the state of preservation of a number of Eternit-Italit asbestos-cement aqueducts which had been in operation for many years. Test results fully confirmed the formula evolved 25 years ago for the mean velocity of flow in asbestos-cement pipes as a function of the diameter of the conduit and of the hydraulic gradient, thus proving that the material had not undergone appreciable changes.

INTRODUCTION

About 25 years ago the Author was first invited by the Eternit Company, Genoa, to make a study of their pipes then in production at the Casale Monferrato Works. The material employed, now well established in Italy and abroad, was at that time very little known.

It must be pointed out here at the outset that a variety of asbestos-cement pipes differing in composition are to be found on the market and that the Author intends to confine his review to the Eternit type normally used for pressure mains and experimented upon as far back as 1925. The conduits in question are formed by depositing and compressing on a metal cylinder numerous layers of an asbestos-cement mix applied continuously by means of an endless conveying felt. This process ensures pipes of homogeneous thickness and internally smooth, which are normally supplied in 3 and 4 metre lengths with both ends machined to size ready for coupling up either by " simplex " or " gibault " joints.

Thirty years after the production of these pipes was first undertaken, it was felt that the state of preservation of those which had been in service for a long period should be ascertained. The task was entrusted to the Author in collaboration with Prof. Enrico CREPAZ, lecturer in applied Chemistry at the Engineering Faculty of Padua University.

The flow tests carried out in 1925 on straight runs of new Eternit pipes were a relatively simple matter. By comparison the new investigation appeared much more complex, as it involved additional factors connected with ageing, leakages, bends, etc. So much so that a detailed test programme had to be drawn up before starting experiments, to which we shall later refer.

SELECTION OF PIPE LINES TO BE INSPECTED

Excluding the more recent aqueducts for which Eternit pipes were supplied, the remaining were made the subject of a thorough inspection, with a view to securing ample details of actual operation, taking into account in each case the composition of the water conveyed, which was analysed by the National Chemical Laboratories.

After much thought, it was finally decided to restrict the survey to six aqueducts, among which the following were included :

(1) Vigevano Aqueduct (Milan)—
Laid 1932.

(2) Basso Piave Aqueduct (Venice)—
Laid 1932

(3) Sestri Levante Aqueduct (Genoa)—
Laid 1925

(4) Genoa Sea-water Aquaduct—
Laid 1923

Here are the main points which have emerged in each case :

VIGEVANO AQUEDUCT :—Built in 1932 for a population of about 20,000, it is some 38 km. long. Eternit pipes were employed throughout varying in diameter from 250 to 60 mm. " Simplex " joints were used. No particular difficulty had to be surmounted in laying the conduits at an average depth of 1·25 metres in alluvial soil. The aqueduct is fed from wells. The water is neutral, displays 3 degrees of hardness and contains iron and manganese hydrates. The pressure head is 50 metres. During the first few years of operation failures of the joints due to bad assembly and inferior quality rubber were experienced. The defects were remedied and have not since recurred.

For the purpose of the inspection which took place on 28th January, 1948, the following were uncovered :—

(*a*) a length of conduit 150 mm. dia. and 9 to 10 mm. thick, which appeared very well preserved from the outside, with joints in perfect condition. After breaking the end couplings it was noted that adjacent pipes were in true alignment and contact. The four packing rings exposed were flat, but, on stretching, three of them responded elastically and tended to resume a circular cross-section ; the third was rather sluggish. The internal surface of the pipe was dark in colour (due to manganese) and much more smooth and specular than that of a new conduit provided for replacement.

(*b*) other two lengths of conduits, 100 and 60 mm. dia. respectively. On inspection they were found in the same perfect conditions of the above.

BASSO PIAVE AQUEDUCT :—Built in 1932 for a population of about 60,000, it is fed from wells supplying water of 10 degrees of hardness. Apart a short steel syphon, the whole of the pipe line—26 km. of it—and of the distributing mains—total length about 100 km.—is in Eternit. Supply head is about 20 metres. It has been laid 1·30 metres deep in soil where sand and clay prevail. No troubles were encountered either in laying or during initial testing. Under actual working conditions, however, failures of pipes were experienced in a section about 3 km. long running over clayey soil. Breakages occurred between September and November after the beginning of the rainy season and could not be attributed to defective materials, as replacement pipes failed likewise. It has been since ascertained that poor bedding and insufficient support in relation to the length of the pipes were the causes.

During the inspection carried out on 28th January, 1948, a length of conduit 600 mm. dia. was unearthed. It appeared in perfectly good state externally. The joints were tight and secure and on breaking them open it was found that the rubber packing rings behaved elastically, although much more markedly in the upper half of the circumference. The pipe inspected was built for a 5 atm pressure head and was orginally tested at 10 atm. The inside surface appeared as smooth as new.

SESTRI LEVANTE AQUEDUCT :— Dates back to 1925 and was built for a population of 10,000. It is fed from wells. Water hardness ; 10·5 degrees. Composition of water : 1 mg. of oxygen per litre ; 15 mg. of chlorides per litre. Oxidizable organic substances are present. The main section of the aqueduct is composed of 200 mm. dia. pipes. Total length : 15 km. using Gibault joints Supply head : 30 metres. Test pressure applied : 7 atm. Both laying and testing was uneventful. Originally all pipes below 50 mm. dia. were of cast iron but had to be replaced later with Eternit owing to bad incrustation.

A length of conduit 200 mm. dia. was uncovered and was found in perfect condition. The bolted joints were dissembled and the packing rings were removed and stretched. Despite the deformation suffered through use they exhibited considerable elasticity. The internal surface of the pipe was coated with a yellowish film, presumably of iron oxide. On scraping, the top layers appeared softer than the underlaying stratum for a depth of a fraction of a mm.

GENOA SEA-WATER AQUEDUCT: It provides water for purposes other than drinking to a restricted number of consumers. Was put into commission in 1923 and is mainly composed of pipes 250 mm. dia., decreasing to 50 mm. dia. in secondary circuits. Joints are of the bolted " gibault " pattern. It was laid in clayey soil without special supports, except that bends were anchored with concrete structures. Supply head in secondary circuits fluctuates between 0 and 10 atm. Test pressures applied : from 5 to 20 atm. Breakages occurred soon after completion but they were due to imperfect bedding and erratic control of supply. It must be borne in mind, moreover, that the mains are subject to variations of head ranging from 32 to 131 metres and that no special provision has been adopted to damp out the steep rise in pressure due to " hammerblow."

The length uncovered for inspection was 100 mm. in diameter and was built for a head of 10 atm. The pipe and its joint were found to be perfectly sound. On dismantling the inside surface appeared smooth and hard, in no way attacked by the liquid conveyed. As to the joint itself, the metal glands did not exhibit appreciable corrosion and the rubber rings behaved elastically. The cast iron sleeve of the joint showed that it had been attacked, where exposed to sea-water, down to a mean depth of 2 mm.

INVESTIGATION RESULTS AND FURTHER OBSERVATIONS

From the foregoing, certain conclusions can be drawn. It is first of all manifest that the Eternit conduit, as well as Simplex and Gibault joints, stands up well to the test of time and is not generally subject to deterioration. The smooth, hard internal surface is particularly resistant to wear, foils incrustation and is unaffected by either " hard " or " soft " waters. Even sea-water—as proved by the Genoa Aqueduct to which reference has been made—

GRAPH PLOTTED TO A LOGARITHMIC SCALE OF FLOW (V) IN FUNCTION OF HYDRAULIC GRADIENT (*i*)

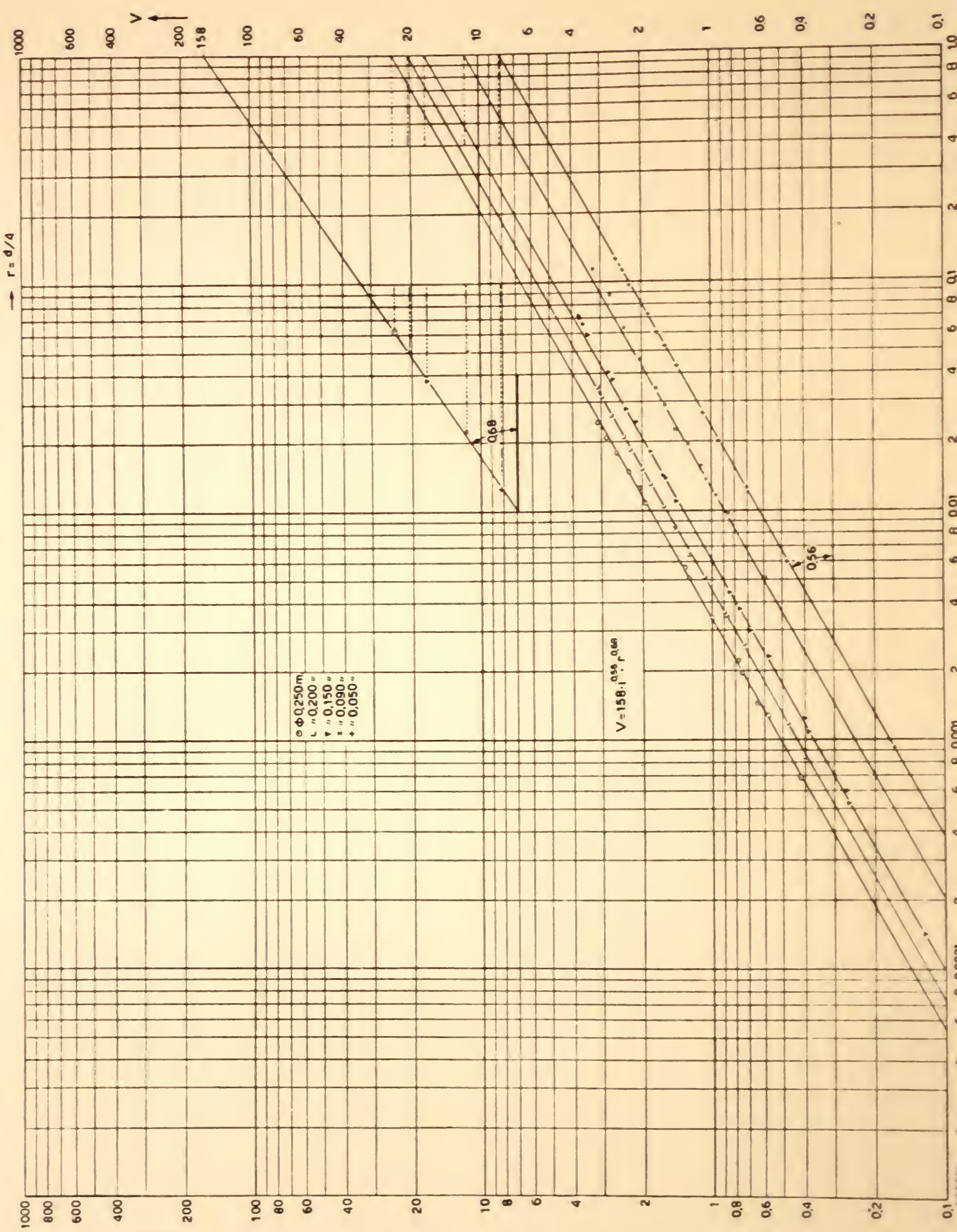


FIG. 7A. V = *Velocity of flow in litres per second* i = *Hydraulic gradient*

can be safely conducted in Eternit. The Eternit pipe has in fact often provided a solution to the problem of conveying corrosive liquids, successfully replacing more orthodox but less suitable materials doomed to decay, as we have observed in the case of the Sestri Levante Aqueduct. This, however, must not be taken to mean that Eternit is immune from all attack. There are liquids particularly harmful to cement, such as water containing high percentages of sulphates and carbon dioxide. Whenever they are encountered the designer is well advised to choose other materials.

One important feature of Eternit mains is that they are eminently suited to withstand the ordeal of fluctuating heads, attention being drawn once again to the Genoa Sea-water pumping main. In this respect the part played by the joints and rubber rings used to couple up the pipe line must not be overlooked. For Eternit asbestos-cement conduits, the " simplex " and " gibault " types are normally employed. They do not comprise parts rigidly fixed to either of two connected pipes and allow therefore considerable deflections at the coupling, yet maintaining an effective seal. The Author actually witnessed some of the tests carried out by the makers on these joints, which, normally rated for 10 atm., were in some cases able to withstand a pressure three times that amount. In fact the pipes burst before any sign of leakage at the joints could be detected.

It was noted that the rubber ring of the joints, even after decades, maintains a large part of its elasticity. Naturally, for rubber certain guarantees are required and the British Standard Institute has issued a somewhat restricted specification for the rubber for Simplex and Gibault joints. The same limitations and other complimentary specifications have been adopted for some time in Italy. It was noticed that there was no difference in the tightness and lasting quality between the two types of joints, Simplex and Gibault.

DISCHARGE TESTS

It is well known that a loss of discharge is to be expected from pipe lines which have been in continuous use for a long period. The loss is due to the general deterioration of materials and to the structural changes undergone by the wetted surface due to the corrosive action of the liquids conveyed. In the worst cases frequent scraping and replacements must be resorted to, often at intervals entirely disproportionate to the length of useful service.

The Eternit asbestos-cement pipes inspected by us, on the other hand, were all found in perfect condition, internally smooth and as good as new in every respect. On the face of it it might have seemed superfluous to subject them to a flow test, yet to dispel all possible doubt the experiment was undertaken.

Conduits from the aqueducts already inspected or from others of the same age were unearthed to be laboratory tested at the Institute of Hydraulics of Padua University, in lengths no less than 40m., comprising four or five pipes each. Conduits of 50 ; 90 ; 150 ; 200 mm. dia. were included. Thus the specimens selected, apart the desirable feature of having been in service for 20 years, afforded a good range of diameters and were representative of waters with different degrees of hardness. They were arranged in a straight line and did not receive any preparatory treatment. Wherever possible the original joints were used : a few proved defective and were replaced with others of identical pattern. Weirs, notches and Venturi meters were used for the flow tests on the larger diameters ; weighing

tanks and chronometers, for the smaller conduits. Pressures were measured by means of piezometers (two or three for each section) suitably spaced and readings tabulated in one table. For particularly small pressure readings sensitivity was increased by resorting to gauges containing nitrobenzene or benzene. Graphs to scale of the readings of each individual piezometer were also drawn so as to expose possible discrepancies at a glance. These, however, proved so small that the mean readings of the end piezometers, spaced 28 metres apart and well away from inlet and outlet respectively, were at all times closely approximated.

Test results have been tabulated in the attached table and plotted to a logarithmic scale in graph of Fig. 7A, from which the relation existing between the hydraulic gradient i and the mean velocity v can be seen. The mean value given by the graph is $v = 158\ r^{0.68}\ i^{0.56}$, where v=Velocity of flow in metres.

r=hydraulic radius of the pipe$=\frac{d}{4}$(metres)

i=Hydraulic gradient or difference of head per metre of pipe line.

It is opportune to revert now to our tests carried out in 1925 on new Eternit conduits, we find that the formula we arrived at then is identical with the value given above, except that the constant has now dropped from 165 to 158. That the indexes of r and i have been confirmed is a very important fact indeed, because it proves the stability maintained throughout the years by the material employed, which for the purpose of the test behaved as if it were new.

When for the purpose of comparison we come to consider the work of other experimenters in the same field, it must be recalled first of all that similar evaluations were effected by the following:—

(1) National Physical Laboratory of Teddington, where $v = 165\ r^{0.68}\ i^{0.56}$ was confirmed although details of the tests were not published.

(2) E. Meyer-Peter, Zurich, who investigated on a 250 mm. dia. conduit.

(3) A. Ludin, Berlin, who experimented on conduits of 50 ; 100 ; 150 ; 200 ; 250 mm. dia.

(4) R. Ehrenberger, Vienna, who employed a single specimen 100 mm. dia.

(5) Hydraulic Laboratory of Lausanne, where three conduits of 60 ; 100 ; and 150 mm. dia. were tested.

(6) E. Neuman and Walter who adopted 100 and 200 mm. dia. conduits.

(7) A. J. Maahs who experimented with a partly wetted conduit of 600 mm. dia.

Very little importance can be attached to the results of the last two experimenters ; the first confined himself to a very narrow range of velocities and the second restricted his survey to a partly filled conduit.

The formulae arrived at up-to-date by different workers are as follows :—

1925 Scimemi (Casale-Padova), on new pipes $v = 165\ r^{0.68}\ i^{0.56}$

1931 Meyer-Peter (Zurich), on new pipes $v = 135{\cdot}3\ r^{0.68}\ i^{0.526}$

1932 Ludin (Berlin), on new pipes $v = 134\ r^{0.65}\ i^{0.54}$

1938 Hydraulic Laboratory, Lausanne, on new pipes $v = 140\ r^{0.645}\ i^{0.555}$

1950 Scimemi (Padova), on old pipes $v = 158\ r^{0.68}\ i^{0.56}$

The test procedure adopted in each case was by no means standard. Thus Meyer-Peter's formula was based upon investigation on a single conduit 250 mm. dia. That of the Hydraulic Laboratory of Lausanne refers to pipes only 2·50 m. long, whereas the usual length of Eternit

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ETERNIT ASBESTOS-CEMENT PIPES

Sestri Levant Aqueduct Diameter 0,050 m. r = 0,0125 m. Temperature 19° C.			Ostra Aqueduct Diameter 0,090 m. r = 0,0225 m. Temperature 18° C.			Monferrato Aqueduct Diameter 0,150 m. r = 0,0375 m. Temperature 13° C.			Sestri Levant Aqueduct Diameter 0,200 m. r = 0,050 m. Temperature 22° C.			Genoa Sea-water Aqueduct Diameter 0,250 m. r = 0,0625 m. Temperature 25° C.		
Q l/s	V m/s	i	Q l/s	V m/s	i	Q l/s	V m/s	i	Q l/s	V m/s	i	Q l/s	V m/s	i
0,32	0,163	0,000926	3,753	0,59	0,005089	2,181	0,123	0,000142	12,4	0,394	0,000833	20,50	0,418	0,000683
0,935	0,476	0,006000	5,43	0,854	0,009678	4,59	0,26	0,000528	14,6	0,464	0,001166	28,20	0,574	0,001277
1,395	0,710	0,01266	6,11	0,96	0,011627	4,70	0,265	0,000599	20,2	0,642	0,00200	31,5	0,641	0,00144
1,839	0,936	0,02000	6,75	1,061	0,013628	6,85	0,387	0,00109	22,6	0,719	0,002583	36,7	0,747	0,001968
2,140	1,090	0,02660	7,095	1,115	0,01572	7,10	0,401	0,00125	26,8	0,853	0,003416	37,8	0,770	0,00223
2,763	1,407	0,04300	8,067	1,268	0,01930	10,15	0,574	0,00232	27,4	0,872	0,003571	43,6	0,990	0,00341
3,109	1,583	0,05233	9,074	1,426	0,02254	12,25	0,693	0,00297	33,4	1,063	0,005083	61,8	1,259	0,00512
3,362	1,712	0,06020	10,10	1,587	0,02399	13,45	0,761	0,00373	39,2	1,247	0,006437	64,2	1,308	0,00573
3,659	1,863	0,07211	10,994	1,728	0,03408	14,90	0,843	0,00440	39,2	1,247	0,006333	94,48	1,925	0,01083
4,407	2,244	0,09650	12,922	2,031	0,04528	25,20	1,426	0,0110	44,6	1,419	0,008333	101,53	2,068	0,01251
4,734	1,411	0,1125	15,111	2,375	0,06303	28,10	1,590	0,0138	44,8	1,426	0,0085	112,54	2,292	0,01489
5,040	2,566	0,1261	17,40	2,735	0,08715	28,70	1,624	0,01425	50	1,591	0,01031	127,18	2,591	0,01794
—	—	—	20,50	3,222	0,1135	32,50	1,839	0,0182	56,6	1,801	0,01292	139,84	2,849	0,02094
—	—	—	—	—	—	37,4	2,116	0,0245	62,0	1,973	0,015	153,22	3,121	0,02431
—	—	—	—	—	—	41,40	2,342	0,0278	69,6	2,215	0,01816	—	—	—
—	—	—	—	—	—	47,20	2,671	0,03775	74,04	2,356	0,0207	—	—	—
—	—	—	—	—	—	49,3	2,790	0,0408	83,80	2,667	0,02583	—	—	—
—	—	—	—	—	—	60	3,395	0,0585	91,59	2,915	0,03108	—	—	—
—	—	—	—	—	—	61	3,452	0,0588	96,31	3,065	0,03425	—	—	—
—	—	—	—	—	—	63,60	3,599	0,0660	—	—	—	—	—	—
—	—	—	—	—	—	65,60	3,712	0,0700	—	—	—	—	—	—
—	—	—	—	—	—	66	3,735	0,0720	—	—	—	—	—	—

Q = *Discharge in litres per second*

V = *Velocity of flow in metres per second*

i = *Hydraulic gradient or difference of head per metre of pipe line*

pipes is of 3 m. up to 100 mm. dia., and 4 m. for larger diameters. They obviously could not be accepted for general work. The Ludin equation, on the other hand, affords a useful comparison with our own. On the strength of a paper published by Ludin himself in 1932, it would appear that his formula is a better interpretation of the experimental results known up to that time (including ours). Yet it must be pointed out that in Ludin's formula the indexes of r and i do not appear to be related in agreement with the fundamental laws of similitude which in the $v = k\, r^p\, i^q$ should make $3q - 1 - p = 0$.

It is of course true that in dealing with experimental data it is perhaps unwise to make them fit a preconceived law, yet when the accordance is already there no objection can possibly be raised. Our own test results of 1925 and 1950 easily fall into place ; and so it must be said of Ludin's results. In fact if our formula is applied to Ludin's experiments the value $v = 162\, r^{0.68}\, i^{0.56}$ is obtained with an approximation by no means less pronounced than that given by Ludin's formula (for velocities above 0·50 metres per second).

Thus the reliability of our line of approach having been confirmed, we are of the opinion that the formula which enables the velocity of flow to be determined with the highest degree of accuracy is $v = k\, r^{0.68}\, i^{0.56}$.

It is now well time to account for the discrepancies observed in the value of k which was given by us as 165 in 1925, by Ludin as 162 in 1932 and by us as 158 in 1950 ; Perhaps it would have been fair to assume that the differences noted from 1925 to 1950 were due to ageing. After all they amounted to a mere 5 per cent. over a period of no less than 20 years. Yet our explanation to-day points in another direction. Having in fact observed that the value obtained for k, by referring Ludin's experiments to our formula, is 162, as against 165 found by us in 1925, we are led to believe that the larger figure was due to metering inaccuracies in the earlier tests. It is in fact recalled that the Bazin type of weir was employed in 1925 and that the working formula supplied by Bazin himself gives values which are notably on the high side especially with small flows, which was exactly our case. Thus the conviction has now emerged that the 5 per cent. discrepancy between 1925 and 1950 cannot be attributed to ageing of the Eternit internal surface but rather to the inaccurate metering technique of 25 years ago.

In conclusion we believe that for all Eternit pipes, old and new, truly laid in a straight line the formula $v = 158\, r^{0.68}\, i^{0.56}$ holds good. From it $q = 48{\cdot}3\, d^{2.68}\, i^{0.56}$ is derived, where q is discharge in litres per second and d is the diameter of pipe in metres.

NOTE : *Professor Scimemi refers to Asbestos-Cement pipes by the original trade name of Eternit which is still used for the home market in Italy. For all Eternit products exported the separate trade name of " Italit " is used.*

"ITALIT" ASBESTOS-CEMENT PIPES IN OPERATION

1. 14 IN. (350 MM.) DIA. PIPE-LINE WITH SIMPLEX JOINT FOR A HYDRO-ELECTRIC SCHEME AT ZOLEZZI (ITALY)
2. 16 IN. (400 MM.) DIA. PIPES WITH GIBAULT JOINT IN HYDRO-ELECTRIC SCHEME IN N. ITALY
3. 40 IN. (1000 MM.) DIA. PIPE-LINE AT TERNI
4. "ITALIT" PIPES OF VARIOUS DIAMETERS AS CABLE-DUCTS AT GENOA

TECHNICAL REPORT ON "ITALIT" PIPES

By SIR ALEX BINNIE, SON and DEACON

(Now Messrs. Binnie, Deacon and Gourley) Chartered Civil Engineers

AS long ago as 1925 a report on " ITALIT " pipes was made by this well known firm of consulting engineers, concluding with the following brief summary :—

1 Our partner, Mr. H. F. J. Gourley, arrived in Italy on 13th December last. The object of his visit was to report impartially on the asbestos-cement pipes as manufactured at Casale Monferrato under the trade name "ETERNIT" for Italian supplies and "ITALIT" for foreign supplies. He saw the process of manufacture, carried out a number of tests and inspections, and discussed the usefulness and application of asbestos-cement pipes with a number of well-known Italian engineers who had had experience in the laying of such pipes.

2 We found that already there was a very considerable and growing demand for Asbestos-Cement Pipes for Water, Gas and Sanitary Engineering, and that considerable savings followed their use, in the place of other materials. We might mention that in 1923 the supply was 35 miles of various sizes; in 1924, 47 miles; and in 1925, 87 miles.

3 We inspected the process of manufacture and the resulting product is a tough straight pipe with a glossy regular and truly circular interior, which permanently retains these characteristics.

4 The pipes are not liable to deterioration, in ground which would cause trouble with metal pipes, nor are they likely to suffer loss of carrying capacity. They are also immune from the effects of stray electric currents.

5 They offer a smaller resistance to the flow of water than new coated cast iron pipes laid under the best conditions.

6 They are easily tapped for small connections, and offer less difficulty than metal for larger connections.

7 They are lighter, more easily laid, and more readily jointed than cast iron.

8 They call for cast iron adaptors at valves and for specially thickened spigots on bends owing to their greater thickness than cast iron, but, owing to the flexible joints which may be used with them and the readiness with which they may be cut, the number of bends is not as large as would be required with a cast iron main.

9 Given good pipe laying, the pipes are amply strong enough for any loading to which they may ordinarily be subjected and are capable of successfully withstanding a considerable amount of rough usage.

10 We consider that for working pressures up to 300 ft. of water and for diameters up to about 15 ins., mains of asbestos-cement are 45 to 25 per cent. less costly, laid completely, than if cast iron were used, provided that the mains compared have the same ultimate carrying capacity.

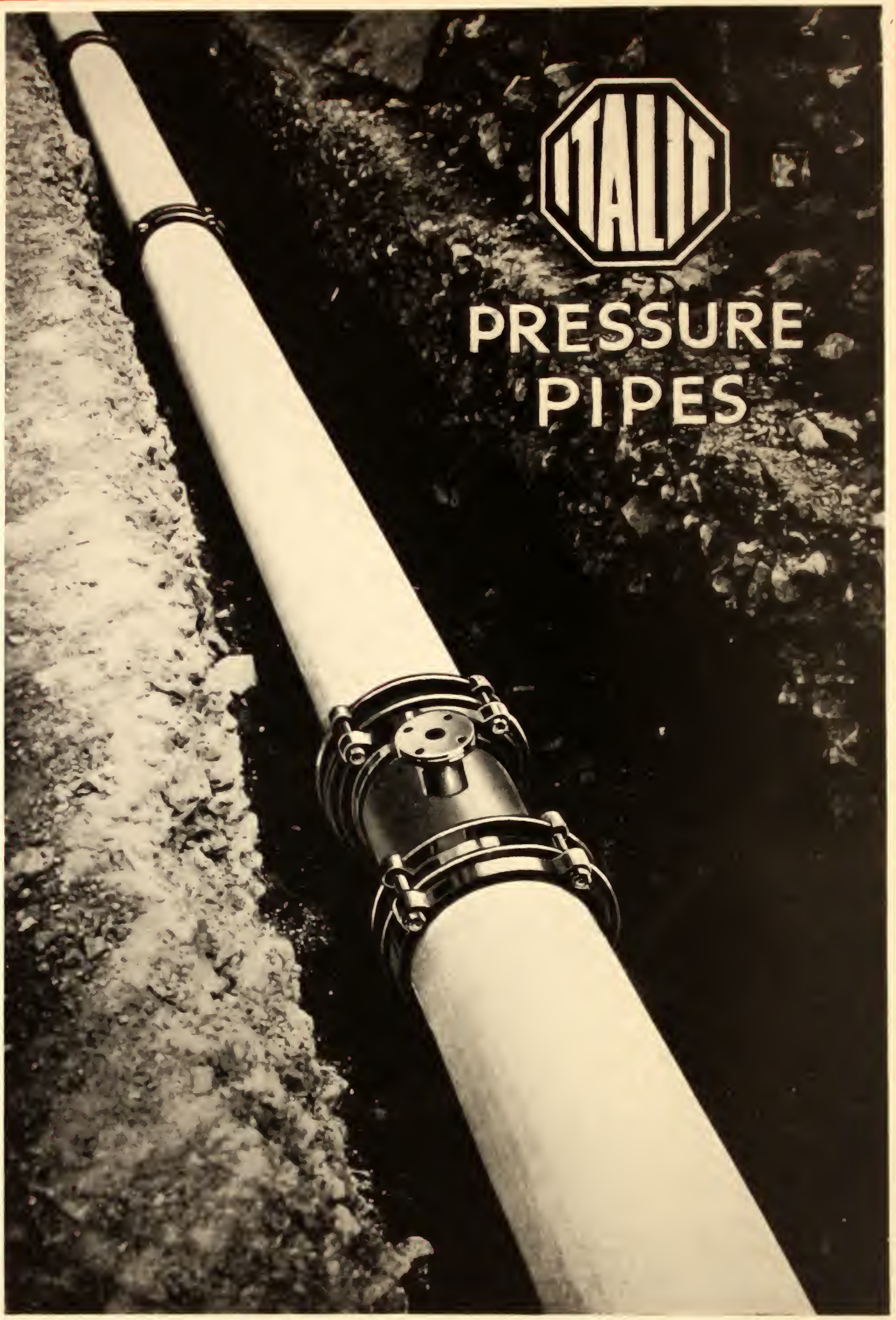
These savings are exclusive of the cost of trench excavation and refilling, which is common to both. For smaller working pressures, asbestos-cement pipes above 15 ins. in diameter can compete successfully with cast iron pipes.

11 Asbestos-cement pipes are also suitable and economical for use as gas mains, sewers and drains, oil pipe lines and cable ducts.

ITALIT

ASBESTOS-CEMENT

PRESSURE PIPES


ITALIT
PRESSURE
PIPES

THE USES OF "ITALIT" PRESSURE PIPES

"ITALIT" asbestos-cement pipes have been advantageously employed in almost every field where fluids and gases are to be conveyed, e.g.

WATER SUPPLY AND DISTRIBUTION MAINS
SALT WATER AND BRINE MAINS
SEWER RISING MAINS AND PRESSURE SIPHONS
GAS MAINS
OIL PIPE-LINES
INDUSTRIAL PROCESS PIPE-LINES
HOT AND MINERAL WATER PIPE-LINES

SOME OF THE ADVANTAGES

(1) DURABILITY. The raw materials, asbestos and cement, are chemically inert, robust and immune from deterioration through decay and bacterial action. The resulting product does not disintegrate or deteriorate in the ground and its strength actually increases with age.

Tests on "ITALIT" pipes in use for 30 years, showed them to be still in perfect condition, stronger than when newly laid, all evidence suggesting that they have a practically unlimited life.

(2) STRENGTH. Owing to their special process of manufacture and the selected quality of the materials composing them, "ITALIT" pipes offer great strength to all the various stresses which they may have to sustain. The minimum guaranteed bursting, crushing and bending loads are given in the following chapters. When employed at working pressures up to one half of the test pressures indicated for each class, they offer a safety factor entirely adequate for all practical purposes.

(3) IMPERMEABILITY. "ITALIT" asbestos-cement pipes, being impermeable to water and bacteria, are ideally suited for use as water supply and distribution mains, as well as for sewerage and other uses.

Bitumen or other coatings are not required to guarantee perfect watertightness.

(4) LOW FRICTIONAL RESISTANCE. "ITALIT" pipes have a smooth, glossy, truly cylindrical internal surface, and offer very low hydraulic frictional resistance to the flow of liquids.

Experimental data show that the carrying capacity of "ITALIT" pipes is on an average 25 per cent. greater than that of new cast iron pipes, and 30 per cent. to 60 per cent. greater than that of old cast iron pipes, all being of the same internal diameter.

(5) NON-TUBERCULATING. One of the major problems in the water undertaking industry today is the progressive reduction of carrying capacity in iron pipes due to tuberculation or incrustation. The growth of nodules or tubercles inside pipes, first increases the friction losses and may later reduce the effective cross section of the pipe by as much as 50 per cent. in the course of a few years.

To offset the effects of tuberculation, engineers make allowance for this reduction of carrying capacity by installing pipes of larger diameter than would otherwise be necessary. This is not a remedy but only an expensive expedient. As tuberculation progresses and the loss of flow increases, pressures throughout the transmission and distribution lines will be cut, unless pumping rates are increased. In gravity systems compensation for drops in pressure is not usually possible except by the laying of new pipes.

In any case cuts in the service, or greater pumping costs, are the consequences of tuberculation to the point that renewal of entire sections of a reticulation may become imperative.

With "ITALIT" pipes there are no such dangers; their smooth glossy interior surface and their initial high flow coefficient are indefinitely maintained.

(6) NON-CORRODING. "ITALIT" pipes are unaffected by the ordinary corrosive agents encountered in soils or waters which attack metal pipes, and cause their destruction, often in the course of a few years.

FIG. 8.—"ITALIT" PIPES 10 IN. (250 MM.) DIA. AFTER 27 YEARS SERVICE IN THE GENOA SEA-WATER ACQUEDUCT. NOTE THE EXCELLENT CONDITION OF THE EXTERNAL AND INTERNAL SURFACES, FREE FROM CORROSION, EROSION, TUBERCULATION.

(7) IMMUNITY FROM ELECTROLYSIS. Having a non-metallic composition, "ITALIT" pipes are immune from stray electric currents. This is an invaluable feature in all areas where electrolytic conditions are prevalent.

(8) THERMAL INSULATION. The thermal insulating capacity of asbestos-cement being approximately hundred times greater than iron, "ITALIT" pipes do not need to be protected from extremes of temperature by deep laying or lagging as in the case of metal pipes.

(9) LIGHT WEIGHT. As "ITALIT" asbestos-cement pipes are relatively light in weight (on an average less than one half of cast iron), the handling, transport and laying costs can be greatly reduced. More pipes can be carried per truck-load ; fewer men are required for handling. In diameters up to 16 ins. Class "B," the unloading from the truck, lowering into the trench, and alignment of the pipes

can be performed without the use of mechanical equipment other than ropes. Two men can easily carry a standard 4 m. length (13 ft. $1\frac{1}{2}$ ins.) of 8 ins. Class "B" "ITALIT" pipe by hand. As a result fewer man-hours are required for handling and laying.

FIG. 9.—SHOWING EASY HANDLING OF "ITALIT" PIPES.

(10) TIGHT AND FLEXIBLE JOINTS. The joints as supplied with "ITALIT" asbestos-cement pipes (described from page 27 to 33) are perfectly watertight, and can be rapidly assembled without the use of skilled labour. They permit of angular deviations thereby allowing negotiation of long radius bends without the use of special pieces.

Being so flexible they permit movement of the pipes under natural ground settlement without impairing watertightness.

The coupling requires no heating equipment and can be assembled under practically any trench conditions.

Assembling can be checked in a few seconds by merely gauging the position of the rings.

(11) FEWER SPECIALS. The angular deviation permitted by the Simplex, Gibault, and Monolithic socket type joints, enables a reduction to be made in the number of special bends required.

By cutting the pipes into shorter lengths, curves of long radii can be obtained without use of specials as indicated on page 88.

(12) FEWER JOINTS. The standard length of "ITALIT" pipes being greater than that of other non-metallic types, fewer joints

are required, resulting in economy and speed of laying. Safer service is also a consequence of fewer joints.

(13) EASY TO WORK. "ITALIT" asbestos-cement pipes can be easily cut, drilled and tapped with ordinary tools, thus eliminating material and labour wastage.

FIG. 10

FIG. 11

(14) ECONOMY. By employing "ITALIT" pipes, it is possible to realise an initial saving of 25 per cent. to 40 per cent. in comparison with cast iron pipes having the same carrying capacity for the following reasons :—

Smaller diameter of pipe necessary.
Lower cost.
Lower freight and transport costs.
Cheaper laying and jointing.

The economy effected in the course of time proves, however, to be far more important, as the immunity of "ITALIT" pipes from tuberculation and encrustation not only ensures maintenance free service in this respect, but also low pumping costs. The great durability of "ITALIT" pipes, which are free from the effects of corrosion and electrolysis, gives a much longer life than metal pipes and eliminates the inconvenience and expense of stoppages, cleaning, repairs and replacements.

The use of one of the "ITALIT" flexible joints which absorb ground settlements, vibration and water hammer without damage or leakage being sustained by the pipe-line, further contributes to the smooth and safe working of the system cutting maintenance costs to almost nil.

PHOTOGRAPHS SHOWING CONDITION OF "ITALIT" PIPES AFTER 20–30 YEARS SERVICE

1. GENOA SEA-WATER MAIN 10 IN. (250 MM.) DIA. WITH GIBAULT JOINT AFTER 27 YEARS.

2 AND 4. 32 IN. (800 MM.) DIA. PIPES FROM THE SCALENGHE (TURIN) WATER MAIN AFTER 22 YEARS USE.

3. 24 IN. (600 MM.) DIA. PIPES OPENED UP FOR INSPECTION BY PROFESSOR SCIMEMI AFTER 20 YEARS SERVICE. PIPES AND SIMPLEX JOINTS WERE FOUND TO BE IN PERFECT CONDITION INTERNALLY AND EXTERNALLY. THE RUBBER RINGS HAD PRESERVED THEIR ORIGINAL ELASTICITY.

5. CAST IRON PIPES AFTER 10 YEARS USE SHOWING HOW TUBERCULATION AND CORROSION AFFECTS THESE PIPES.

JOINTS & SPECIALS FOR USE WITH "ITALIT" ASBESTOS-CEMENT PRESSURE PIPES

FOUR types of joints, all being flexible, are offered for coupling "ITALIT" asbestos-cement pipes. *They are*:—

THE SIMPLEX ASBESTOS-CEMENT JOINT

THE CAST IRON DETACHABLE GIBAULT JOINT

THE MONOLITHIC SOCKET

THE LEAD JOINT

The three first mentioned joints employ rubber rings as a sealing agent: these rings fulfil all the recognised basic requirements to ensure that the rubber has an indefinitely long life, viz., they are kept damp, cool, protected from light and are in compression. As one example of the long life which may be expected of rubber, a gasket removed from a Brooklyn (New York) water main, is in a good state of preservation after 69 service years and continues to retain its elasticity.

The great progress made in the manufacture of rubber products in the last decades further contributes to the already long established life of rubber in pipe-lines.

THE SIMPLEX ASBESTOS-CEMENT JOINT is available for all diameter pipes in Class A and B, for diameters up to 28 ins. in Class C, and up to 18 ins. in Class D. It is simple, efficient, inexpensive and almost

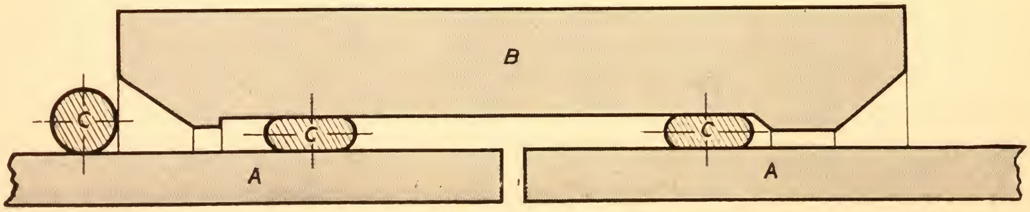


FIG. 12.—LONGITUDINAL SECTION OF HALF SIMPLEX JOINT (B) IN POSITION ON PIPE ENDS (A). NOTE SECTION OF RUBBER RING (C) BEFORE AND AFTER ASSEMBLY.

fool-proof. It consists of an "ITALIT" asbestos-cement sleeve accurately machined and provided with internal grooves, and two rubber rings. This joint can be made with great ease and despatch ; when assembled the rubber rings are tightly compressed between the pipe and the sleeve, forming a flexible yet perfectly bottle-tight connection. Angular deviations between adjoining pipes of 4° to 16° according to diameter are possible with the Simplex joint, thus allowing for planned deviations without the use of special pieces, and for movements of settling ground without damage being caused to the pipe-line. To allow for such movements and for pipe expansion a space of approximately $\frac{1}{4}$ in. must be left between the butt-ends of the pipes.

FIG. 13.—SIMPLEX JOINT SECTIONED TO SHOW RUBBER RINGS IN POSITION.

FIG. 14.—A PRACTICAL EXAMPLE OF THE ANGULAR DEVIATION PERMITTED BY THE SIMPLEX JOINT. A 32 IN. (800 MM.) PIPE-LINE IN SERVICE.

This joint is assembled as follows :

(1) The sleeve is slipped over the end of the pipe to be joined.

(2) The two rubber rings are then placed on the end of the same pipe at a distance between them, equal to the length of the sleeve.

(3) Having drawn the two butt ends of the pipes together and in alignment, the sleeve is pulled over the two rubber rings rolling them into the correct position with the sleeve centred over the pipe ends. This operation is quickly and easily effected by hand, or in the case of large diameter pipes, by a simple puller provided for the purpose.

Fuller details on how to assemble this joint are given on page 91.

The Simplex joint after 25 years experience has been proved to withstand even under adverse conditions the guaranteed pressures without the least leakage. Since no metal enters into its construction, it is free from corrosion, and once laid can be forgotten.

Dimensions and weight of the Simplex joint are given in Table X, page 67.

THE CAST IRON DETACHABLE GIBAULT JOINT is available for all diameters and classes of pipes, and is recommended for coupling Class E and F pipes and all cast iron specials. It consists

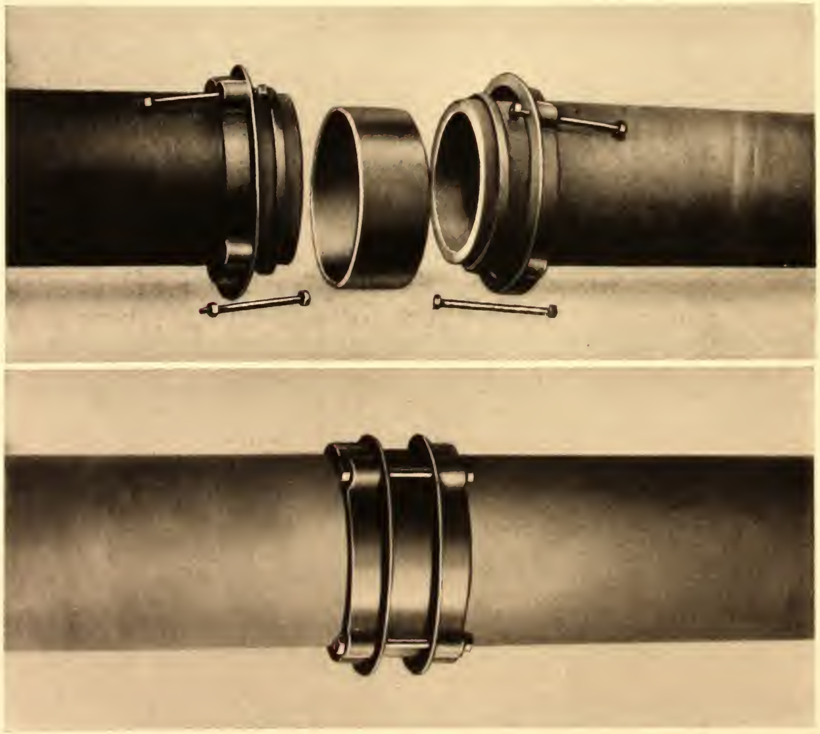


FIG. 15.—THE GIBAULT JOINT BEFORE AND AFTER ASSEMBLY.

FIG. 16.—24 IN. (600 MM.) DIA. "ITALIT" MAIN WITH GIBAULT JOINT SHOWING BEND OBTAINED BY CUTTING PIPES INTO SHORT LENGTHS, THUS OBVIATING USE OF CAST IRON SPECIALS.

of one collar and two flanges of cast iron, two rubber rings and wrought iron bolts. This joint is easily assembled, and when in service is perfectly water-tight and flexible permitting, angular deviations of 4° to 22° according to diameter. To allow for this and for pipe expansion a space of ¼ in. to ½ in. must be left between the butt ends of the pipes. As shown in Figure 15 the Gibault joint is assembled by placing one loose flange, followed by one rubber ring on the end of each pipe; the sleeve is put on one of the pipes and the butt ends are then drawn together; finally the flanges are bolted, compressing the rubber rings against the sleeve, thus making the complete joint. This joint is universally used throughout the world and its efficiency is well established. As in the case of the Simplex joint it is easily and quickly made without the use of skilled labour.

Dimensions and weights of the Gibault joint are given in Table XI, page 68.

THE MONOLITHIC SOCKET CUP TYPE JOINT is available for pipes Class A and B up to 6 ins. diameter.

It is produced exclusively by "ITALIT" and eliminates the use of separate couplings. This joint consists of a cup-ended pipe with one rubber ring as sealing agent. The socket is separately manufactured by the same process as the pipe and joined to it by machine immediately the two are produced. This socket differs from other asbestos-cement cup-type joints in the very fact that the two pieces are so mated before cement hardening commences that a complete one-piece structure, able to withstand the guaranteed pressures, is obtained.

Jointing is effected by placing one rubber ring on the plain end of one pipe and then forcing the socket of the other pipe to be connected, on to the ring until it is rolled to the correct position.

It is recommended that the space left between the ring and the socket mouth be filled, with a bituminous mastic ~~cement mortar,~~ thus avoiding the entry of foreign bodies and keeping the joint in its correct position.

As with the other types of joint, the Monolithic socket offers flexibility and speed of laying.

FIG. 17.—THE MONOLITHIC SOCKET JOINT CUT TO SHOW POSITION OF RUBBER RING.

THE FLEXIBLE LEAD JOINT is available for pipes Class A, B, C and D up to 20 ~~24~~ ins., for Class E ~~up to 20 ins.,~~ and Class F up to 12 ~~14~~ ins., and is recommended for the coupling of pipes used for conveying certain gases or fluids which may act as a solvent upon rubber.

It consists of a lead sleeve and two cast iron flanges. The sleeve has the

shape of a double truncated cone, the bases being at the centre and the extremities tapered; it has external and internal circumferential grooves. The flanges have a conical interior designed to fit over the sleeve, and their abutting surfaces are bevelled to allow for angular deviations of up to 2° when the joint is completed. The assembling of the joint is simple and performed manually without the use of heating equipment. The loose flanges are first slipped one on each pipe, the lead sleeve is then placed on one pipe and the butt-ends drawn together,

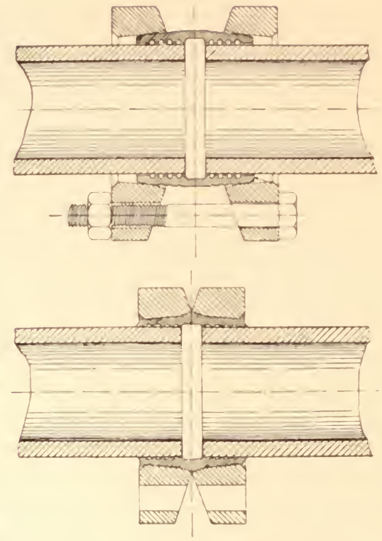


FIG. 18.—LONGITUDINAL SECTIONS OF THE FLEXIBLE LEAD JOINT BEFORE AND AFTER ASSEMBLY.

care being taken as to alignment. The flanges are then tightened by means of bolts (which when assembly is completed can be removed). As they approach each other, the flanges compress the lead sleeve uniformly around the pipes thus forming a joint which is perfectly tight against both internal and external pressures and which allows pipe movements due to ground settlement or vibration. The joint is completed by caulking the two lead rings protruding beyond the cast iron sleeves.

FIG. 19.—9 IN. (225 MM.) DIA. WATER MAIN SHOWING LEAD JOINT IN USE.

THE SCREWED JOINT is available in either asbestos-cement or cast iron. It is used where other types of joints are unsuitable, e.g. for vertical installation of " ITALIT " pressure pipes in wells, mines, etc.
This joint is available for pipes in diameter up to 10 ins. (250 mm.).

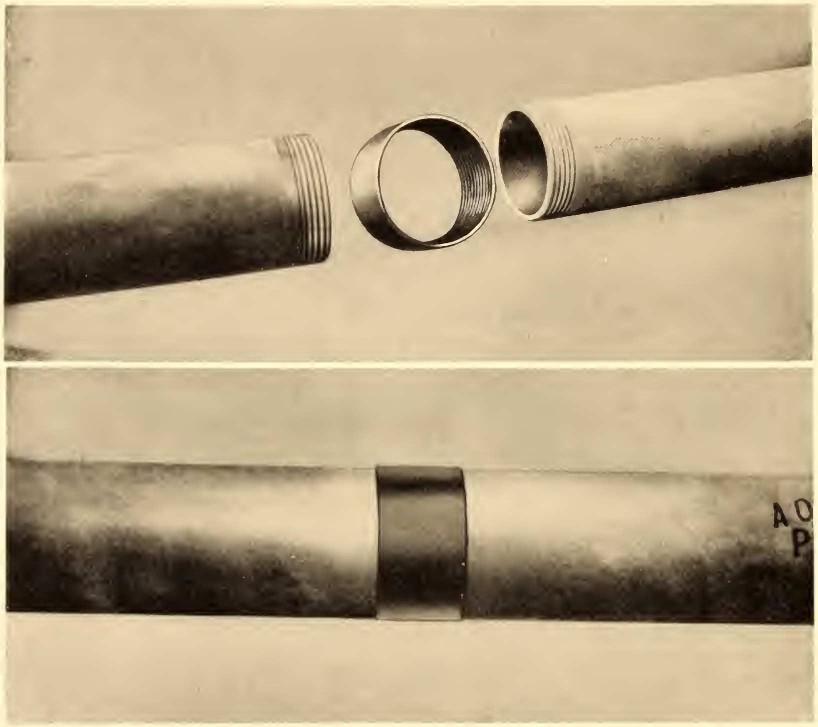


FIG. 20.—THE SCREWED SLEEVE JOINT BEFORE AND AFTER ASSEMBLY.

CAST IRON SPECIAL PIECES with plain ends and saddle piece connections as illustrated on the following page, are made to suit all classes and diameters of "ITALIT" pipes. Diminishing tees and cross pieces are also available.
Experience has shown that the range of specials illustrated covers all normal requirements.
Specials with flanged or socketed ends can be supplied on request.
The Gibault joint is recommended for connecting Cast Iron Specials to " ITALIT " pipes.

Tables of dimensions and weights are given on pages 70–73.

CAST IRON SPECIALS
FOR "ITALIT" ASBESTOS-CEMENT PRESSURE PIPES

NOTE: FOR SIZES OF THESE SPECIALS, SEE TABLES XIII AND XIV

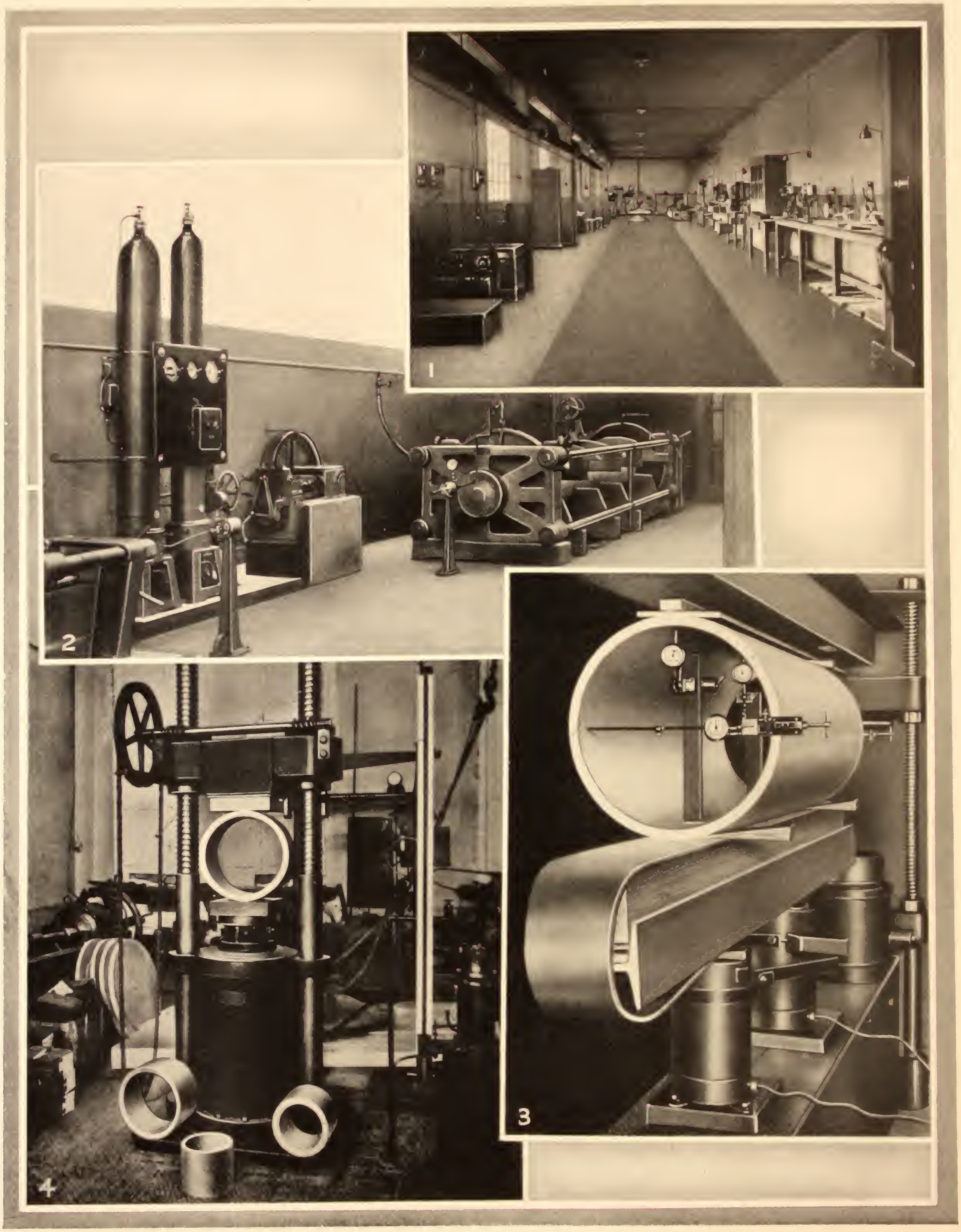
TECHNICAL AND EXPERIMENTAL DATA FOR

ITALIT

ASBESTOS-CEMENT

PRESSURE PIPES

TESTING FACILITIES FOR "ITALIT" ASBESTOS-CEMENT PIPES



1 AND 2. LABORATORY FOR PHYSICAL TESTS AND MACHINERY FOR PRESSURE TESTS ON LARGE DIAMETER PIPES AT THE "ITALIT" WORKS

3 AND 4. MACHINES FOR CRUSHING TESTS

THE PHYSICAL PROPERTIES OF "ITALIT" PIPES

THE outstanding quality and physical properties possessed by "ITALIT" pipes are due: (a) to the grade of asbestos fibre and cement employed in their manufacture, possessing the requisite properties necessary to ensure a product of great strength and unlimited durability; (b) to the manufacturing process in which the pipe is spun in continuous strongly compressed spirals ensuring that the asbestos fibres, which act as a reinforcing agent in the cement, are best arranged for absorbing the tensile stress set up by the internal pressure.

In all stages of production "ITALIT" pipes are strictly and scientifically controlled by observations and systematic tests carried out daily in the fully equipped laboratories of the Company, and periodically in the laboratories of State Schools of Engineers.

"ITALIT" pipes weigh approximately **119 lb./cu. ft. (1,900 kg./m.^{3})** and possess an exceptionally compact and homogeneous structure which ensures their high strength under the various stresses as specified in the following chapters. Tests show that the tensile strength of "ITALIT" pipes is approximately four times that of test pieces composed wholly of high grade Portland cement having the same degree of maturity, **i.e. 3,200—3,400 lb./sq. in. (225—240 kg./cm.^{2})** as against 850 lb./sq. in. (60 kg./cm.^{2}). The strength and the deformation of asbestos cement-pipes under stress depend on their diameter and wall thickness, as well as on age.

Up to a certain point, a long period of maturing improves the pipe strength, depending on various factors such as the temperature and degree of moisture of the surroundings.

The following graph shows the increase of tensile strength in pipes under normal conditions for periods up to 360 days.

The curve shows a substantial increase in strength for the first three

months, the value of the tensile breaking strength then being 92 per cent. of the value at 12 months.

"ITALIT" pipes are normally ready for delivery two months after manufacture, but in view of their age hardening property shown in the graph reproduced, it is recommended that they should not be subjected to their full test pressures until 90 days after manufacture.

The elastic limit of asbestos-cement being in proximity to the breaking point, permanent structural deformation of the pipe can occur only under stresses having a value greater than two-thirds of the breaking stress.

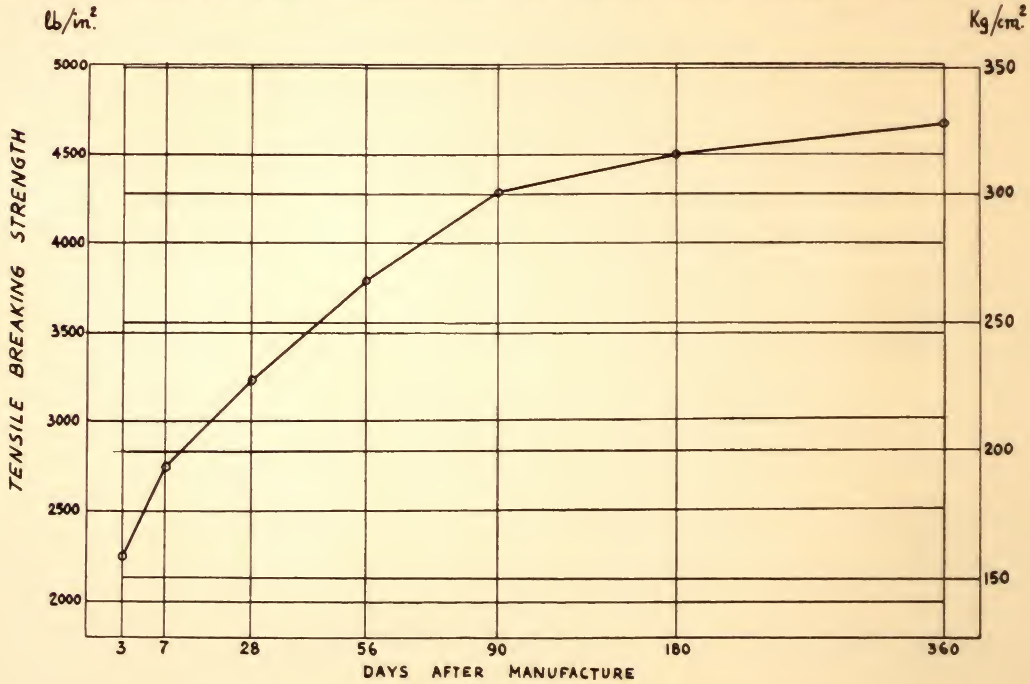


Fig. 21.—*Graph showing the ultimate tensile strength of* "ITALIT" *pipes after varying periods of maturing time. (Average results of tests on* "ITALIT" *pipes Class C* 125 *mm.* (5 *ins.*) *diameter* ; 11 *mm. thick.*)

The employment of coated or specially processed asbestos-cement pipes is recommended only when they are to come into contact with strongly corrosive soils or fluids.

In all normal cases, pipes in their natural state are preferable.

THE CARRYING CAPACITY OF "ITALIT" PIPES

IN 1925 Professor E. Scimemi (Principal of the School of Engineers of the State University of Padua) made the first scientific experimental study in order to establish formulæ for the frictional losses due to flow in asbestos cement pipes.

An experimental plant consisting of four "ITALIT" pipe-lines, 50 mm., 150 mm., 300 mm. and 400 mm. internal diameters, each 100 metres long was set up at Casale Monferrato (Italy).

For each pipe-line and for various velocities of flow, Professor Scimemi established the total loss of head due to friction by gauging differences of pressure between the ends of each pipe-line.

Comparing the results with figures from the formulæ of Darcy, Flamant, and Bazin, Professor Scimemi found that those formulæ, established in the main for metallic pipes, are unsatisfactory for asbestos-cement pipes. He therefore made a theoretical experimental study of his own and established the following new exponential formula :—

$$\mathbf{V = C\, r^{0.68}\, i^{0.56}} \qquad \text{in which:—}$$

V = velocity of flow (ft/sec.) (m/sec.).
C = a constant.
r = hydraulic mean depth = $\frac{D}{4}$
D = diameter of pipe (ft.) (m.).
i = hydraulic gradient.

For pipes laid and jointed according to the best practice C has the value 165 (metric units) or 241 (British units). Only minor differences from the formula were established in tests carried out later by Ludin in Berlin, by Stuky in Lausanne and by Meyer Peter in Zürich.

In England, too, tests were carried out in 1937 at the National Physical Laboratory at Teddington on pipes which were not perfectly aligned, and these tests further confirmed the accuracy of the Scimemi formula.

" ITALIT " pipes are not liable to reduction of carrying capacity due to incrustation, therefore there is no need to make allowances for old pipes. There are " ITALIT " pipes that have been in use for the last 30 years or more in a number of water mains in Italy, and a case of reduction of flow, due to growth or incrustation has never occurred.

The constant C was found to be unchanged in field experiments with pipes carefully laid and jointed and in true alignment.

Since the above conditions are seldom obtained in practice, it is recommended, as a margin of safety suggested by experience, that the value of C be reduced by about 4 to 8 per cent. taking into account the diameter of the pipes (for small pipes greater tolerance is necessary), the care with which they have been aligned and jointed, and the nature of the water to be conveyed.

To facilitate the calculation of frictional losses and rates of discharge, a logarithmic chart based on the Scimemi formula has been worked out and is attached at the end of this book.

This chart is valid for all types and classes of " ITALIT " pipes, provided that they lie below the hydraulic gradient.

The velocity of flow can also be approximately verified on the chart.

IMPORTANT NOTE : while this volume was being printed, Professor Scimemi completed an exhaustive series of experiments on the water flow in " Italit " Asbestos-Cement pipes which had been in service for over 20 years, in five different representative water mains. (See report on page ~~86)~~ 16A–16H).

As a conclusion of his experiments he found that the correct value of the constant C in the above formula, *both for new and old pipes* is 158 (metric units) or 230 (British units). This represents a reduction of approximately 5% in the discharge as given in the attached chart drawn by Professor Scimemi using a constant C=165. Therefore, the allowance of 5% appearing in the following examples should be intended as a correction of the above constant and not to take into account imperfect laying as stated.

EXAMPLES OF THE USE OF THE SCIMEMI'S LOGARITHMIC CHART

Example I

TO DETERMINE THE DISCHARGE from a pipe line of given diameter and length in which the total friction loss is known.

DATA :	Length of pipe line	=	7,000 ft. (2,133·6 m.)
	Internal diameter	=	9·84 ins. (250 mm.)
	Total friction loss	=	21 ft. head (6·4 m.)

CALCULATION : The hydraulic gradient is $\frac{21}{7{,}000} = 0{\cdot}003$ $\left(\frac{6{\cdot}4}{2{,}133{\cdot}6} = 0{\cdot}003\right)$, or the loss of head = 0·3 ft. per 100 ft. (0·3 m./100m.) of pipe. Reducing this value by 5 per cent. to take into account imperfect laying, a loss of head due to friction = 0·285 ft. per 100 ft. (0·285 m./100 m.) of pipe is obtained. From the chart it will be found that when the loss of head is 0·285 ft. per 100 ft., the discharge from a pipe 9·84 ins. (250 mm.) diameter is approximately 610 gallons (2773 litres) per minute, and the velocity of flow about 3·1 ft. (0·95 m.) per second.

Example II

TO DETERMINE THE DIAMETER of a pipe line of given length, in which the total permissible loss of head and the required rate of discharge are known.

DATA : Length of pipe line - - - - - - = 12,000 ft. (3,657·6 m.)
Required rate of discharge - - - - = 270 gallons (1,227·41 litres) per second
Total permissible loss of head from friction = 48 ft. head (14·63 m.)

CALCULATION : The hydraulic gradient is $\frac{48}{12{,}000} = 0{\cdot}004$ $\left(\frac{14{\cdot}63}{3{,}697{\cdot}6} = 0{\cdot}004\right)$, or the permissible loss from friction is 0·4 ft. per 100 ft. (0.4 m./100 m.). Reducing this value by 5 per cent. to take account of imperfect laying, a value 0·38 ft. per 100 ft. (0·38 m./100 m.) is obtained. From the chart it will be found that when the loss of head due to friction is 0·38 ft. per 100 ft., a pipe 6·89 ins. (175 mm.) diameter will deliver approximately 280 gallons (1,273 litres) per minute, which is just over the required rate of discharge. The chart also shows that the velocity of flow will be approximately 2·9 ft. (0·88 m.) per second.

Example III

TO DETERMINE THE TOTAL LOSS OF HEAD due to friction in a pipe line of given diameter and length, in which the rate of discharge is known.

DATA : Length of pipe line - - - - - - = 3,000 ft. (914·4 m.)
Internal diameter - - - - - - - = 31·50 ins. (800 mm.)
Rate of discharge - - - - - - - = 4,000 gallons (18,184 litres) per minute

CALCULATION : From the chart it will be found that when a pipe 31·50 ins. 800 mm. diameter delivers 4,000 gallons per minute the loss of head is 0·035 ft. per 100 ft. (0·035 m./100 m.) of pipe. Increasing this value by 5 per cent. to take account of imperfect laying, a loss of 0·03675 ft. per 100 ft. (0·03675 m./100 m.) is obtained. The total loss of head in the main, due to friction and imperfect laying is therefore $0{\cdot}0003675 \times 3{,}000 = 1{\cdot}1$ ft. (0·335 m.). The velocity of the flow is approximately 2 ft. (0·61 m.) per second.

RESISTANCE OF "ITALIT" PIPES TO INTERNAL AND EXTERNAL PRESSURE

The average breaking stress caused by internal hydraulic pressure

= **3,200–3,420 lb./in.² (225–240 kg./cm.²)**

The average breaking stress caused by external load

= **8,500 lb./in.² (600 kg./cm.²)**

Therefore, assuming a factor of safety of **three** the permissible working stresses are respectively :—

1,070 to 1,140 lb./in.² (75-80 kg./cm.²) for internal hydraulic pressures and 2,840 lb./in.² (200 kg./cm.²) against external loads.

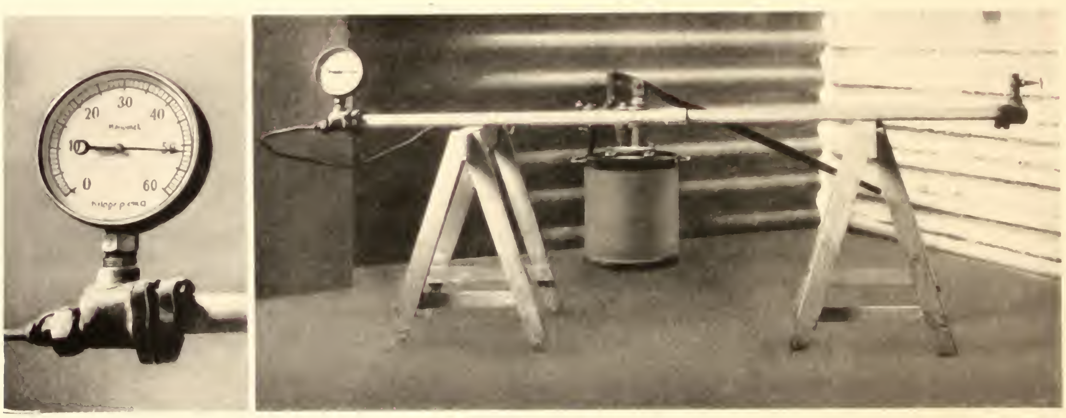


FIG. 22.—TWO "ITALIT" 50 MM (2 IN.) DIA. CLASS D PIPES WITH SIMPLEX JOINT UNDER A TEST TO BURSTING. THE GAUGE SHOWS A WATER PRESSURE OF 51 KG/CM² (725 LB./SQ. IN.)

THE RESISTANCE OF "ITALIT" PIPES TO TENSILE AND BENDING FORCES

TWO sets of experiments* were devised to investigate the resistance of pipes to tensile and bending forces applied together. The first set determined that the sum of the stresses, due to these two forces, required to collapse a pipe remained practically constant, and the second set obtained the separate controlling values of these stresses for collapse.

(*) *Experiments by professor E. Casati (State University of Genoa)*

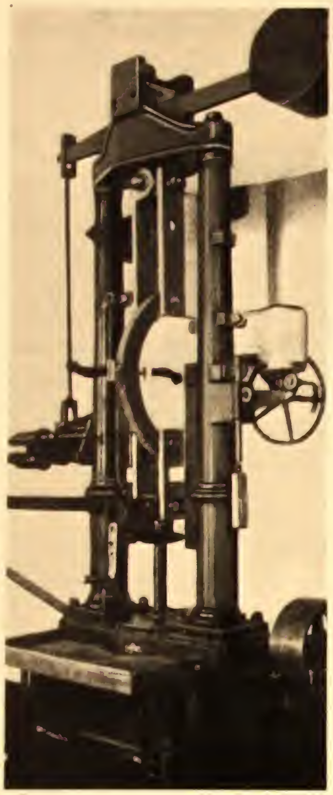


FIG. 23

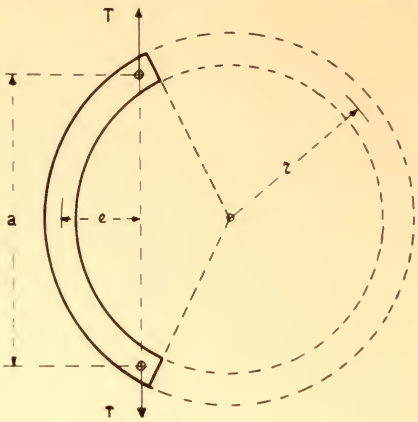


FIG. 24

THE FIRST SET OF EXPERIMENTS consisted of subjecting a number of arc shaped test pieces cut from "ITALIT" pipes of various diameters up to 25 ins. to tension until they failed (see Figures 23 and 24). This tension caused a bending moment M = Te, which reached a maximum value across the centre section. By testing with pieces of varying arc lengths, and therefore altering the bending moment, it was possible to assess the combined effects of tensile and bending forces. It was found that the sum of the stresses due to the tension and due to the bending moment remained constant for each type of pipe whatever their relative values.

The results obtained are summarized in the following table, III, in which, to facilitate comparison the values of the total breaking load T are always referred to pieces 10 cm. wide.

TABLE III

Internal diameter of pipe *mm.*	a *mm.*	e *mm.*	s *mm.*	T *kg.*	M = −Te *cm. kg.*	*Stress due to tensile force* *kg./cm.²*	*Stress due to bending force* *kg/cm.²*	*Sum of stresses* *kg./cm.²*
200	194	58·5	27	1,056	− 6,178	39	551	590
200	150	30	27	1,958	− 5,874	72	522	594
300	252	63	39·4	1,845	−11,623	47	501	548
300	200	37·5	39	2,970	−11,137	76	476	552
300	153	23	39·2	4,430	−10,199	113	438	551
500	395	90	33·2	1,075	− 9,675	32	551	593
500	350	66	32	1,370	− 9,042	43	550	593
500	250	31	32	2,700	− 8,370	84	511	595
600	445	95	33	1,045	− 9,927	32	572	604
600	397	72	33	1,372	− 9,878	42	574	616
600	300	40	33	2,350	− 9,400	72	541	613

General average = **8,320 lb./in.² (585 kg./cm.²)**

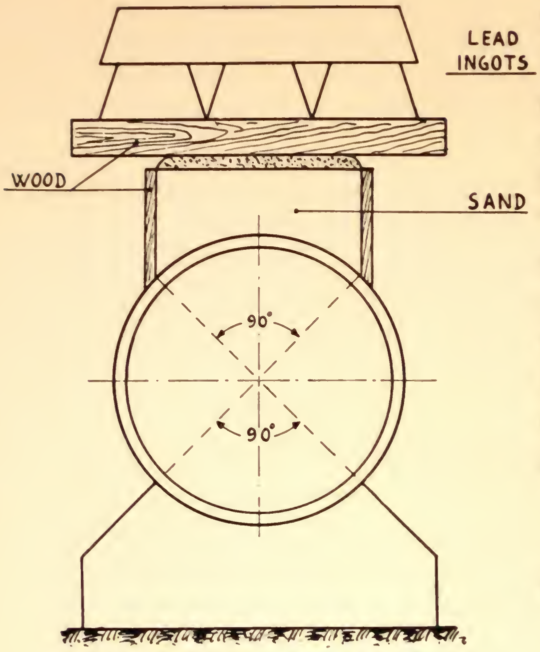


FIG. 25.

The stresses due to the tensile and bending forces in the above experiment are exactly similar to those set up in practice when a pipe is subjected to internal hydraulic pressure and an external load. Taking the minimum figure of the sum of the stresses in the above table as 7,800 lb./in.² (550 kg./cm.²) and a factor of safety of 3, the following equation is therefore valid for pipes in practical use, subject however to the limitations set out on page 46 :—

$$2{,}600 = \sigma_1 + \sigma_2 \text{ (in lb./in.}^2\text{)} \qquad \text{(A)}$$

$$185 = \sigma_1 + \sigma_2 \text{ (in kg.cm.}^2\text{)}$$

where : σ_1 = stress due to internal hydraulic pressure.

σ_2 = stress due to external load.

THE SECOND SET OF EXPERIMENTS consisted of determining the stress needed to cause a whole pipe to collapse when subjected to a known constant external load.

Figure 25 shows the method of external loading, the lengths of the pipes tested being 6 ft. The results are summarized below in the following table and graph :

TABLE IV

Internal diameter "d" *mm.*	*Thickness* "t" *mm.*	*External load* *kg./m.*	$\sigma 2 = \frac{M}{W}$ *kg./cm.²*	*Breaking hydraulic pressure* *kg./cm.²*	$\sigma I = \frac{Pd}{2t}$ *kg./cm.²*
200	10·4	—	—	26	250
	10·4	2,560	250	25	240
	10·4	3,560	348	21·8	210
	10·5	4,700	450	13·5	128
300	13	—	—	22	254
	13	2,670	250	20	231
	13	4,850	450	13	150
350	13	—	—	20	269
	13·7	2,560	250	18	230
	13	3,440	376	16	215

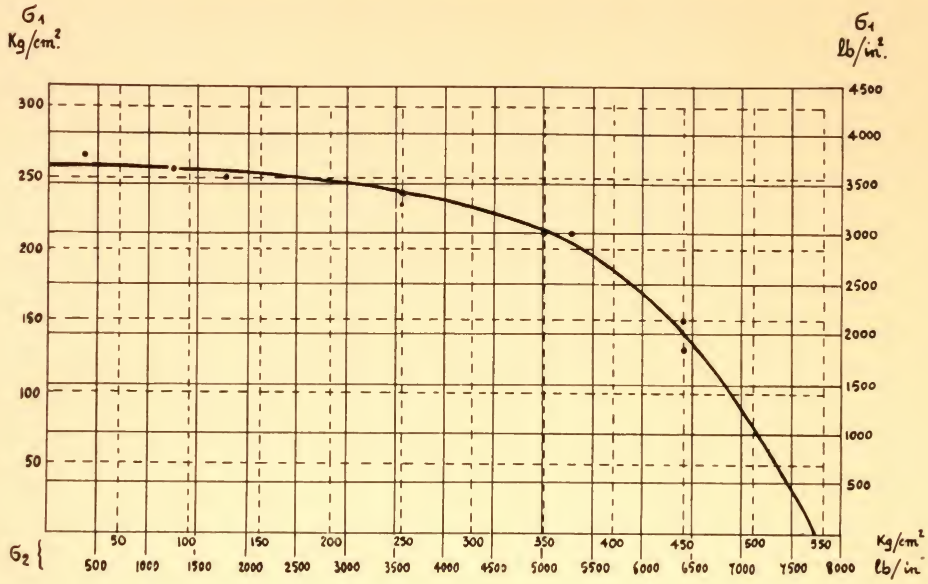


FIG. 26

It can be seen that σ_1 is never greater than the breaking tensile stress under internal hydraulic pressure alone.

Until σ_2 reaches over 4,260 lb./in.^{2} (300 kg./cm^2) the breaking stress is controlled by σ_1, but from just over 300 kg./cm^2 upwards, equation (A) holds.

As the permissible working stress under internal hydraulic pressure (i.e., σ_1) has a mean value of 1,100 lb./in.^{2} (say 80 kg./cm.^{2}), formula (A) should be written :—

$$2{,}600 = \sigma_1 + \sigma_2 \text{ (in lb./in.}^2\text{) or } 185 = \sigma_1 + \sigma_2 \text{ (in kg./cm.}^2\text{)}$$

provided

σ_2 is equal to, or greater than, a value 2,600 − 1,100, i.e., **1,500 lb./in.^{2}** (105 kg./cm.^{2}).

DEPTH AT WHICH "ITALIT" PIPES CAN BE LAID IN THE SOIL

THE above limiting value of $\sigma_2 = 1{,}500$ lb./in.^{2} (105 Kg/cm^2) determines the depth h of the soil, or the equivalent depth h of soil plus any surcharge, over the crown of the pipe (see Figure 27).

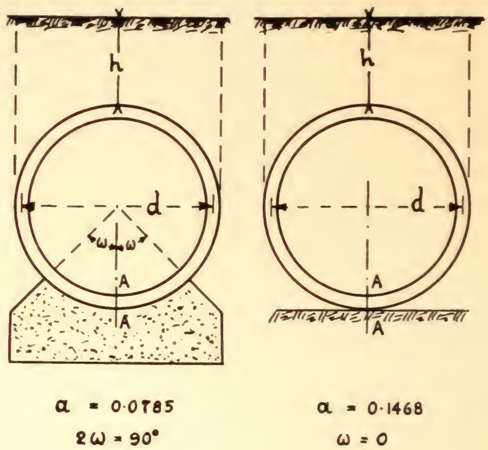


FIG. 27

In the calculations given below, the following assumptions are made :

(1) The effects of the direct stresses in determining the bending moment caused by the external loads are considered negligible.

(2) The thickness of the pipe is small in comparison with the mean diameter.

Let M = Bending Moment on Section A-A (Figure 27).
Z = Section modulus of Section A-A (Unit length of pipe).
P = Total downward load on pipe/unit length.
d = Mean diameter of pipe.
t = Thickness of pipe.
γ = Density of soil (assumed 109 lb./cu. ft. (1,750 kg./m.^{3}).)
h = Depth of soil, or equivalent depth of soil plus surcharge.
a = Numerical coefficient dependent on the conditions of support of the pipe.
= 0·0785 for pipe laid on a supporting cradle covering a quarter of the circumference.
= 0·1468 for pipe assumed resting only on its lowest point.

N.B.—These two cases are the only ones that need be considered, as the pipe is either uniformly supported (a = 0·0785) or not uniformly supported (for which condition a = 0·1468 gives a safe value of h whether the pipe is only supported by a spur or point of rock at the bottom of the trench, or whether it is slightly supported by the rammed earth around).

By not taking into account any lateral pressures due to the earth loading, and neglecting the compressive stress caused on the section sustaining the greatest tensile strength (to disregard these factors is entirely on the safe side and allows greater simplicity in working) the following equations are obtained :—

$$\sigma_2 = \frac{M}{Z} \tag{1}$$

$$M = a\,Pd \tag{2}$$

$$P = \gamma hd \tag{3}$$

$$Z = \frac{1}{6}t^2 \tag{4}$$

therefore $1{,}500 \times 144 = \dfrac{6a\gamma hd^2}{t^2}$ $\qquad 105 = \dfrac{6a\gamma hd^2}{t^2}$ (metric)

$$= \frac{6a\,.\,109\,.\,hd^2}{t^2}$$

therefore $$h = \frac{330}{a}\left(\frac{t}{d}\right)^2 \tag{5}$$

and $\dfrac{t}{d} = \sqrt{330\,ha}$ $\qquad \dfrac{t}{d} = \sqrt{100\,ha}$ (metric) (6)

For pipes in which the thickness is not small in respect to the diameter, it is advisable to obtain the depth h from the formula for curved beams.

The following relationship is then obtained :—

$$h = \frac{990}{a}\,\frac{t}{d}\,\frac{1}{\left[\dfrac{1}{x\left(\dfrac{d}{t}-1\right)}-1\right]} \qquad h = \frac{300}{a}\,\frac{t}{d}\,\frac{1}{\left[\dfrac{1}{x\left(\dfrac{d}{t}-1\right)}-1\right]}\ \text{(metric)} \tag{7}$$

$$\text{where } x = \frac{1}{3}\left(\frac{t}{d}\right)^2 + \frac{1}{5}\left(\frac{t}{d}\right)^4 + \ldots\ldots$$

To assist in calculations, formula (6) for pipes having a small thickness in respect to the diameter has been represented graphically on page 49, giving two curves dependent on how the pipe is supported. Also given are the dotted curves based on formula (7) for pipes whose thickness are n ot small compared to their diameters.

It is obvious that the same curves can also be used when the stress σ_1 due to the internal pressure, is less than 1,100 lbs./sq. in. (80 kg./cm.^{2}). All that is necessary is to multiply the depth h given on the graph by the ratio

$\frac{2,600 - \sigma_1}{1,500}$ (in lb./in.^{2}) or $\frac{185 - \sigma_1}{105}$ (in kg./cm.^{2}).

Example

To determine the permissible depth of soil above an "ITALIT" pressure pipe Class A, 7·87 ins. (200 mm.) diameter; 0·3937 in. (10 mm.) thick working at the pressure 28·44 lb./in.^{2} (2 kg./cm.^{2}) laid on a supporting cradle including an angle $2\omega = 90°$.

DATA : d =	7·87 in.	(200 mm.)
t =	0·3937 in.	(10 mm.)
P =	28·44 lb./in.^{2}	(2 Kg/cm.^{2})

CALCULATION (British units):

$t/d = \frac{0{\cdot}3937}{7{\cdot}87} = 0{\cdot}05$. From the graph on page 49 it will be seen that for $t/d = 0{\cdot}05$, the permissible depth h is approximately 10·5 ft.

The stress due to the hydraulic working pressure is :—

$$\sigma_1 = \frac{P\,d}{2\,t} = \frac{28{\cdot}44 \times 7{\cdot}87}{2 \times 0{\cdot}3937} = \text{approx. } 284 \text{ lb./in.}^2$$

As this is less than 1,100 lb./in.^{2} the depth h can be increased as follows :—

$$h_1 = h\,\frac{2{,}600 - \sigma_1}{1{,}500} = h\,\frac{2{,}600 - 284}{1{,}500} = \text{approx. } 16{\cdot}2 \text{ ft.}$$

The maximum permissible depth of soil above the pipe, is in this case therefore approx. 16 feet.

CALCULATION (Metric units):

$t/d = \frac{10}{200} = 0{\cdot}05$. From the graph on page 49 it will be seen that for $t/d = 0{\cdot}05$, the permissible depth h is approximately 10·5 ft. (3·2 m.).

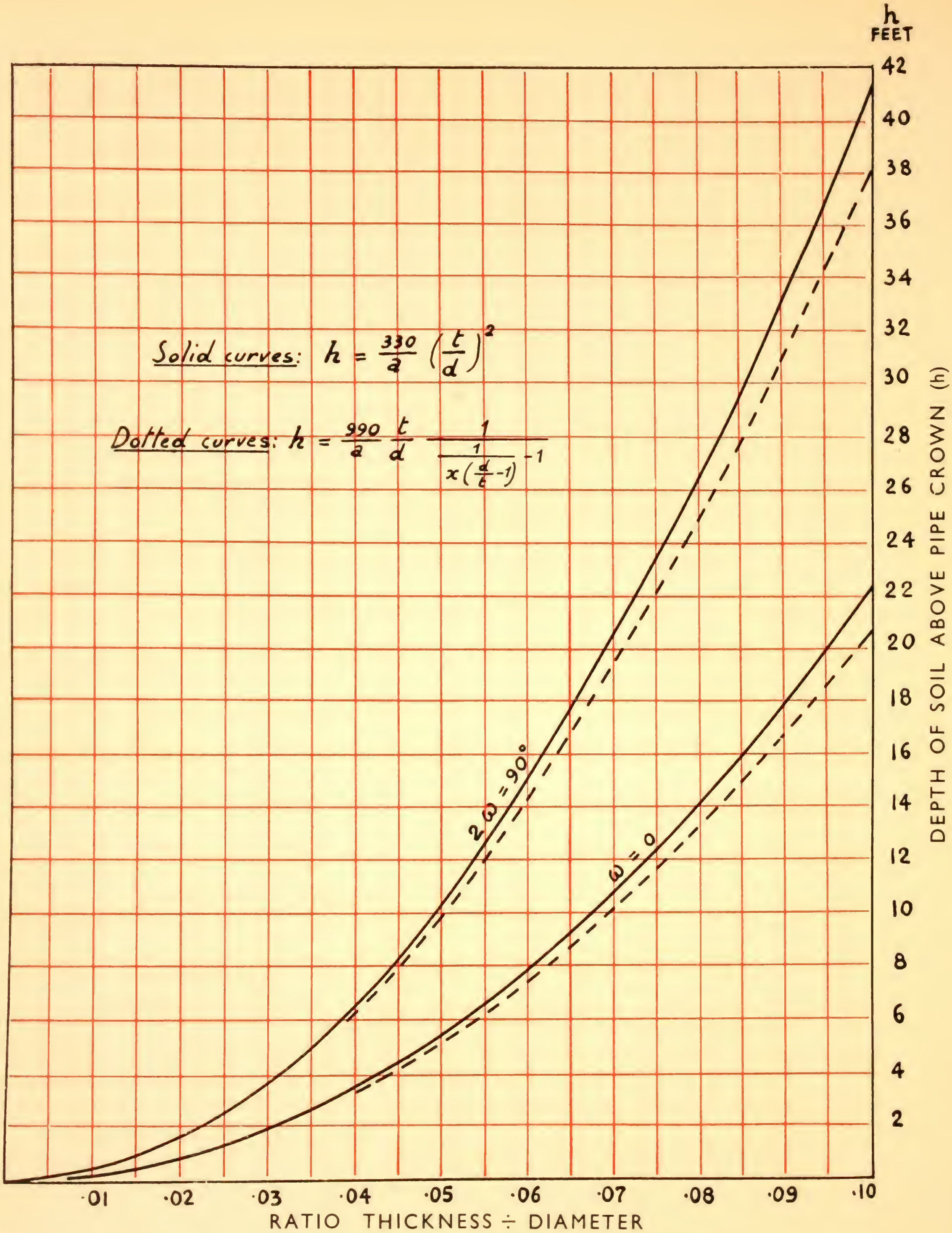
The stress due to the hydraulic working pressure is :—

$$\sigma_1 = \frac{P\,d}{2\,t} = \frac{2{\cdot}20}{2{\cdot}1} = 20 \text{ kg./cm.}^2$$

As this is less than 80 kg./cm.^{2}, the depth h can be increased as follows :—

$$h_1 = h\,\frac{185 - \sigma_1}{105} = h\,\frac{185 - 20}{105} = \text{approx. } 5 \text{ m.}$$

The maximum permissible depth of soil above the pipe, is in this case therefore approx. 5 m.



GRAPH SHOWING THE PERMISSIBLE DEPTH OF SOIL (h) ABOVE "ITALIT" PRESSURE PIPES *in relation to the ratio thickness—diameter in the two cases:—*

(1) *Pipes laid on a supporting cradle including an angle* $2\omega = 90°$.

(2) *Pipes resting only on their lowest point* ($\omega = 0$)—See Fig. 27 and Note on page 46.

THE RESISTANCE TO BENDING OF "ITALIT" PIPES

THESE tests are particularly interesting because in practice, pipes may be subjected to bending.

This occurs, for instance, when the pipes are suspended or laid on supporting cradles or in soil which is not sufficiently rammed and levelled, in which cases they are not supported along their entire length. In these conditions they are subjected to a bending moment.

"ITALIT" pipes are guaranteed to withstand, without failure, a stress due to bending of **4,267 lb./in.^{2} (300 kg./cm.^{2})** when tested in the manner described in the Italian Specifications. This figure is conservative and exceeded under practical conditions.

In this connection it is interesting to note the results of tests to failure under bending carried out* on four "ITALIT" pipes 200 mm. diameter, 3 m. long.

The load was applied in the centre section of the pipes by means of a Mohr and Federhoff horizontal machine adapted for this purpose, and the results were as follows :—

TABLE V

External diameter of pipe *cm.*	*Internal diameter of pipe* *cm.*	*Thickness* *cm.*	*Section modulus* *cm.^{3}*	*Breaking load* *kg.*	*Maximum bending moment* *kg.-cm.*	*Breaking stress* *kg./cm.^{2}*	*lb./in.^{2}*
22·7	19·8	1·45	482·2	2,000	150,000	311	4423
22·7	19·8	1·45	482·2	2,200	165,000	342	4864
22·8	19·9	1·45	496·5	2,150	161,200	325	4622
22·7	19·8	1·45	482·2	2,285	171,000	355	5049

***Average unit breaking stress*=4,739 lb./in.^{2} (333 kg./cm.^{2}).**

* *Tests by Professor Colonnetti (State School of Engineers of Turin).*

RESISTANCE OF "ITALIT" PIPES TO SHOCK VIBRATION & WATER HAMMER

SHOCKS AND VIBRATION

Tests have shown that " ITALIT " pipes are not only tough, but also that they can endure rough usage during handling and are not brittle. During one of the experiments the action of the repeated blows caused perforation of the pipe surface without damage to the adjacent fibres. Figure 28 shows the limited damage.

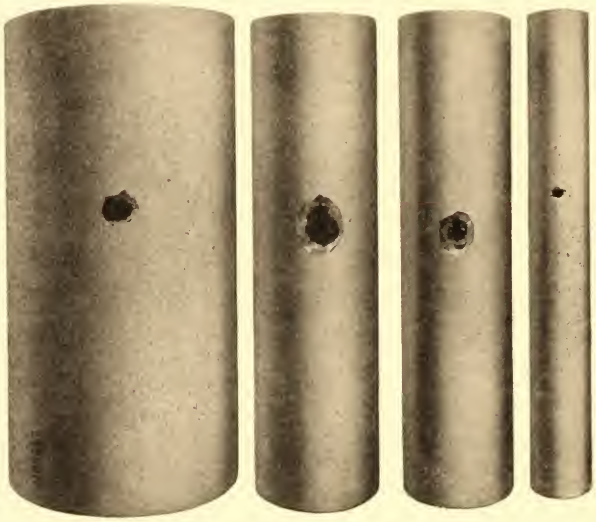


FIG. 28.—PIPES PERFORATED DURING IMPACT TESTS. THE PHOTOGRAPH SHOWS THAT THE DAMAGE IS LIMITED TO THE POINT OF IMPACT

The impact tests were carried out by means of an apparatus consisting primarily of an electro magnet. Iron balls of various weights were lifted by this magnet and dropped on pipes of varying diameters from gradually increasing heights until the pipes were fractured. The energy necessary to produce the breakage of the pipes in relation to their diameter and thickness is given with sufficient approximation by the coefficient $\frac{Ld^2}{t}$ in which L is the amount of energy absorbed by the impact, d is the diameter and t is the thickness of the pipe.

The results of these experiments are summarized in the following table :

IMPACT TESTS

TABLE VI

Internal diameter of pipe	*Thickness of pipe*	*Weight of the ball*	*Height of fall*	*Amount of energy producing breakage*	*Total amount of energy absorbed during breakage*	$\frac{Ld^2}{t}$ *(coefficient of proportionality)*
mm.	*mm.*	*kg.*	*m.*	*kg./m.*	*kg./m.*	
100	12	12	·90	10·8	42	—
200	16	25	1·60	40·0	182	46·60
200	32	25	2·00	50·0	406	41·00
300	24	12	1·80	21·6	115	50·80
400	32	12	1·85	22·2	106	52·00

In addition to the above laboratory experiments, important observations were made during the 1939-45 war, on the behaviour of asbestos-cement pipe-lines under exceptional conditions. In European towns affected by bombing it was observed that asbestos-cement pipe-lines withstood the shocks and pressure vibrations transmitted through the earth, better than cast iron. This can be easily explained by :—

(a) Flexibility of the joints.

(b) Strength and elasticity of the pipes.

There was the example of a heavy bomb falling and producing a large crater within 10 ft. of a 6-in. water main ; no damage or leakage was sustained by the main.

Similar significant proof of resistance was given by asbestos-cement pipe lines during the severe earthquake that shook parts of California in 1940. Several water mains were located in the zones most affected and in spite of the damage reported to pipe lines of other materials, not a single failure in an asbestos-cement pipe line was reported. While admittedly the above examples of evidence are purely circumstantial, they corroborate the observations that the Simplex or Gibault flexible joints permit asbestos-cement pipes to withstand considerable shock and vibration by earth waves.

WATER HAMMER

The following formulæ for predicting the maximum surge of head in cast iron, steel, and asbestos-cement pipes were arrived at in a study* by Professor Russel (Massachussetts Institute of Technology).

(a) For cast iron $\Delta p = (44 \text{ to } 57) \times V$

(b) For steel $\Delta p = (30 \text{ to } 55) \times V$

(c) For asbestos-cement $\Delta p = (25 \text{ to } 41) \times V$

In these short formulæ for approximate values :

Δp = lb/sq. in. maximum pressure due to water hammer

V = Velocity of flow in ft/sec. immediately before sudden valve closure.

(— to —) are derived factors for pipe sizes between 4 in. and 84 in. diameters. The lowest figures apply to 4 in. pipe and the highest to the 84 in. size.

The factors given for the various pipes were determined from the elasticity of the pipe material.

In calculating these values for cast iron pipes a modulus of elasticity of 12,000,000 lbs. was employed, whereas for the asbestos-cement pipe the value of 2,000,000 lbs. was assumed.

Comparative figures for maximum pressures arising from water hammer in cast iron, steel, and asbestos-cement pipes are, for example, 100, 80, and 72 lb./sq. in. (7·0 ; 5·6 ; and 5·0 Kg./cm.^{2}) respectively.

Professor Russel was of the opinion that pipe lines having rubber gasketed joints would build up a lesser maximum pressure, because the pressure wave would be considerably cushioned by the many resilient joint rubbers, acting as a shock absorber.

* *Printed in the March 1941 issue of " Water Works and Sewerage."*

RESISTANCE TO ABRASION OF "ITALIT" PIPES

TESTS,* described below, on the internal surface of "ITALIT" pipes show that they have great resistance to abrasion, and hence are capable of conveying waters containing small quantities of materials such as sand.

Similar tests were repeated on common concrete pipes, and a comparison shows that these latter are far less resistant to abrasive action than the "ITALIT" pipes.

FIRST TEST. An "ITALIT" pipe and a concrete pipe were filled with the same quantity of abrasive material (steel filings), sealed at both ends and rotated horizontally on their own axes. The reduction in weight of the two pipes was measured after an established number of revolutions. The results are summarized below :—

TABLE VII

		"ITALIT" *pipe*	*Concrete pipe*
Internal diameter	mm.	149	148·5
External diameter	mm.	163	210
Length	mm.	130	134
Speed of rotation	revs. per minute	30	30
Abrasive material, No. 5 gauge steel dry filings	kilos.	1	1
Number of revs.	No.	409,300	408,000
Reduction in weight	grammes	1	12·5

SECOND TEST. The internal surface of samples taken from each of the two pipes were submitted to abrasion on a circular area 28.3 sq. cm. by injecting 1 kilo of steel filing No. 5 gauge at a pressure of 21.3 lb./in.^{2} (1.5 atmos.). The reduction in weight of the two samples was :—

(a) "ITALIT" pipe	First test	= 0.8 grammes
	Second test	= 0.9 grammes
(b) Concrete pipe	First test	= 15.7 grammes
	Second test	= 14.5 grammes

* *Tests performed by Professor Santarella (State Polytechnic of Milan).*

RESISTANCE OF "ITALIT" PIPES TO CORROSION & CHEMICAL ACTION

PIPES can be affected both externally and internally by the corrosive agents encountered in soils, and contained in the fluids to be conveyed.

External corrosion is generally caused by the action of acids and salts encountered in the soil. In metal pipes, this action is fostered by stray electric currents, which may originate in almost any soil under certain conditions of acidity and moisture, setting up electrolytic processes. It is possible, even in a limited area, that the corrosive power of the soil may vary greatly. Moreover, a relatively inactive soil may become highly corrosive with an increase in moisture content, or a change in the chemical characteristics due to fertilization, alterations in drainage, etc.

Internal corrosion is caused by the liquids conveyed when they have an acid or alkaline content, as in the case of many mineral waters, process or waste waters or in sewers. It is, therefore, of vital importance that the pipes chosen for any scheme should provide a high resistance to all types of corrosive agents encountered. Due to the permanence and durability of the materials from which they are made, " ITALIT " asbestos-cement pipes possess a high degree of resistance to all forms of corrosion even without protective coatings. As they are non-metallic, they cannot be subjected to galvanic corrosion or electrolysis. The measure of their resistance to acid corrosion is given by the degree of insolubility of the cement entering into their composition, such a degree being dependent upon the stabilization of free lime.

In " ITALIT " pipes this is accomplished by transforming the free lime largely into insoluble silicates, thereby greatly increasing its natural chemical stability.

There are hundreds of miles of " ITALIT " uncoated mains laid in Italy in various types of acid or alkaline soils, or conveying corrosive waters, industrial and domestic sewerage, and their good condition after 25 or more years service provides practical proof of their exceptional resistance to corrosion.

The results of two sets of experiments, under practical conditions as encountered in service are given as follows :—
(1) In the Winnipeg area of Canada, the highly corrosive nature of the soil and the prevalence of electrolytic action, caused, despite all forms of

protection, severe damage to the cast-iron pipes of the City Water Distribution Scheme, conduits of Portland Cement concrete also deteriorated with great rapidity through the action of ground water. In 1932, Asbestos-Cement pipes became available, and were adopted after laboratory tests lasting over a period of twelve months, satisfactorily proving the impermeability of the pipe material to soil corrosion.

A trial line 1,183 feet long, made up of 14 in. and 18 in. Class C pipes was laid in soil known to be particularly corrosive and electrolytic.

After a five year service period the line was excavated and a careful examination made, the City Chemist found no evidence of any deleterious effect by the soil on the pipes, in point of fact the material was harder than when laid five years previously. In 1946, after 14 years service, exhaustive investigations into the condition of the pipes were undertaken in conjunction, by the City Authorities and the Johns Manville Corporation, at the same time the Pitometer Company of New York made tests to determine the loss if any in the flow capacity of the pipeline.

The results of these tests have been briefly summarised as follows in an article by W. D. Hurst, City Engineer, Winnipeg, Canada, printed in the March 1951 issue of "Water & Water Engineering":

(1) There was no loss of flow capacity over the fourteen-year period.

(2) External and chemical examinations showed that no softening of the pipe had taken place.

(3) Pressure tests of two sections of the pipe showed that they failed at 325 and 430 lb./sq. in. internal pressure. (The maximum pressure carried in the Winnipeg distribution system is 80 lb./sq. in.)

(4) No leakage occurred from the coupling and pipe when tested at 260 lb./sq. in.

(5) The pipe sustained a maximum external load of 10,260 lb. before crushing.

(6) Corporation cocks were inserted into the pipe wall and pulled out in the testing machine. The pipe resisted a force of 4,610 lb. before

breaking outward and freeing the Corporation cock. Examination of the specimen showed that the blowout was normal, that is to say the thread in the pipe did not strip and failure occurred by the actual pulling out of the pipe wall material itself.

(7) Soundness of the rubber rings was substantiated by the results of the pressure tests. Careful inspection of these rings showed them to be free from any signs of deterioration and from pits or cracks. The liveliness and recovery of these rings upon stretching and twisting was found to be the equivalent of new ones.

FIG. 30.—SECTION OF A 10 IN. (250 MM.) "ITALIT" UNCOATED SEWER PIPE AFTER 17 YEARS SERVICE. NOTE THE INTERIOR SURFACE UNAFFECTED BY THE CORROSIVE ACTION OF THE LIQUIDS CONVEYED.

(2) The National Bureau of Standards of the U.S.A. carried out water absorbtion, density, crushing and bursting tests* on asbestos-cement pipes buried for periods of two to four years in fifteen different types of corrosive

* *Reported in the Research Paper* 1602-1944 *by K. H. Logan* and *M. Romanoff.*

soils covering a range in PH from 2.6 to 9.4 and resistivity from 62 to 18,000 ohm-cm. (approximately the extreme limits shown by soils).

The data did indicate that the pipes generally gained in strength during exposure to the soils ; when there was some softening of the surface—noted especially in the acid soils—it was only superficial and the material immediately under the softened outer layers was found to be of the same density as the rest of the specimen.

IMPERMEABILITY AND ANTI-BACTERIA PROPERTIES

As "ITALIT" pipes are formed by a continuous spiral of asbestos-cement compacted into a homogeneous material, they are perfectly waterproof.

If there was any porosity in a pipe, not only would there be loss of the liquid being conveyed, but there would also be danger that liquids containing germs could seep through from the outside when (as may happen in water mains) a negative pressure occurs, causing an inward suction.

With regard to experiments relating to penetration by bacteria we print the two following statements :—

(a) The search for B. Coli was always negative and the bacterial flora of the water on in-flow and out-flow from "ITALIT" pipes never showed any variation in quantity or quality as to suggest that the liquid and bacteria in contact with the external walls of the pipes had permeated into them.*

(b) In "ITALIT" mains the bacterial contents of drinking water decreases whereas in other pipes it usually increases. Pathogenic organisms which may cause serious water borne epidemics, soon decrease in vitality when placed under experimental conditions in "ITALIT" pipes. Therefore it is fair to assume that "ITALIT" pipes from a hygienic point of view are superior to those of a ferrous composition.†

* *Report by Professor Missiroli (Bacteriology and Micrography Laboratory of the Board of Health Rome).*
† *Report by O. Casagrandi (Professor of hygiene at the Medicine Faculty of the University of Padua).*

CONVEYANCE OF GAS

Conclusions reached after experiments* on "ITALIT" pipes conveying gas:—

(1) Standard " ITALIT " pipes, filled with coal gas and surrounded by air, allow diffusion between gas and air in different measure.

(2) The degree of moisture of the pipes has a great bearing on the phenomena of diffusion, the greater the moisture the smaller the permeability, the latter becoming nil when the pipe is kept wet.

(3) In standard " ITALIT " pipes laid underground (as is usual in the case of gas mains), diffusion tends to become negligible—in such conditions the loss is only about a third of a cu. ft. per sq. ft. (100 litres/sq. m.) per annum.

(4) If standard " ITALIT " pipes are bituminized (or treated with some other suitable substance) the average loss is also in the neighbourhood of a third of a cu. ft. per sq. ft. (100 litres/sq. m.) per annum, even when laid in the open.

As the result of experiments, over many years, the manufacturers of " ITALIT " pipes have recently succeeded in producing a special asbestos-cement pipe, for the conveyance of all types of gas, which is perfectly gas-tight without the need of a bituminous coating, even when laid in the open air.

In this new pipe the whole thickness of the walls is subjected to a special treatment directed to fill the capillary spaces of the material. The advantages of this treatment over bitumination are obvious. In fact the layer of bitumen covering pipes may be erased off externally and damaged internally by corrosive deposits, whilst in the case of " ITALIT " special gas pipes such danger is eliminated.

For these special " ITALIT " pipes the same guarantees of gas-tightness current for cast iron pipes are given, namely a loss not greater than **0·328 cu. ft. (100 litres) of coal gas or 0·547 cu. ft. (175 litres) of hydrogen per sq. ft. per annum,** at a pressure of 6 ins. head of water (0.015 Kg./cm^2).

The Gibault or the Lead flexible joint can be employed for the coupling of " ITALIT " gas pipes.

The expert advice of the Technical Department of the " ITALIT " Works on all problems relating to the construction of " ITALIT " gas mains under various conditions, is at the disposal of clients.

* *Carried out by Professor M. G. Levi and G. Monti (State Polytechnic of Milan).*

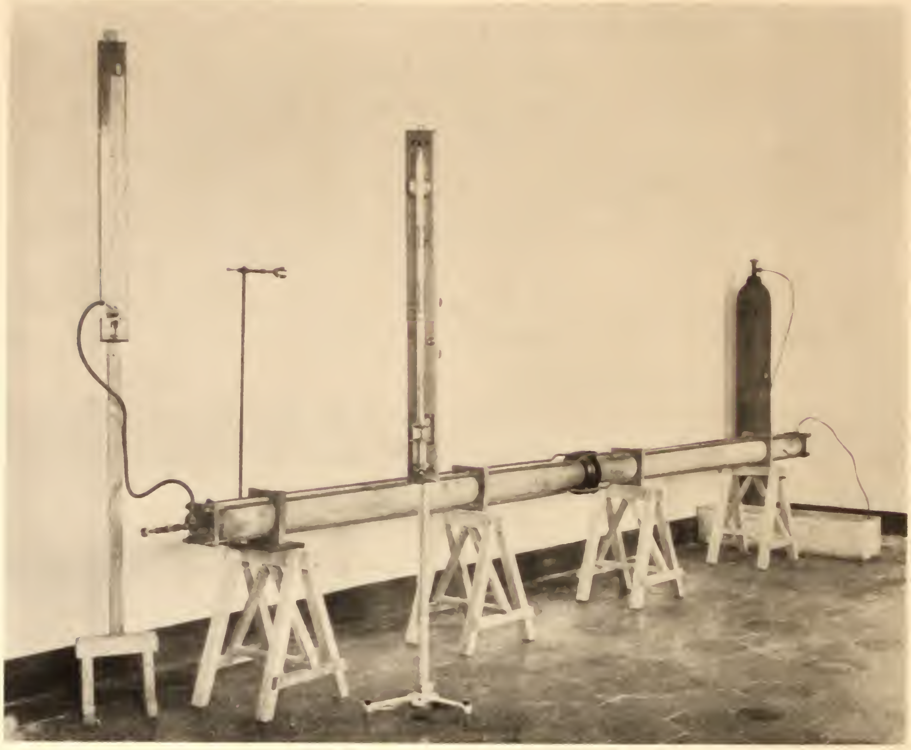


FIG. 31.—"ITALIT" GAS PIPES UNDER TEST TO IMPERVIOUSNESS

FIG. 32.—"ITALIT" GAS MAIN AT VERONA

CALORIMETRIC DATA

COEFFICIENT OF HEAT EXPANSION. The average coefficient of heat expansion **a** of " ITALIT " pipes is :—

$$a = 88 \times 10^{-7}$$

Example of calculation :

To determine the expansion in diameter and length of an " ITALIT " pipe 4 m. (13.12 ft.) long, 150 mm. (5.91 ins.) internal diameter, 14 mm. (0.55 in.) thick, with a temperature variation of 100° C. (180° F.).

Diameter expansion = 150 mm. x 0.0000088 x 100 = 0.132 mm. (0.005 in.).

Length expansion = 4 m. x 0.0000088 x 100 = 0.00352 m. (0.138 in.).

These quantities are negligible.

The Simplex and Gibault flexible joints, used with " ITALIT " pipes, allow for the expansion of each length of pipe, even under great variations of temperature.

COEFFICIENT OF HEAT TRANSMISSION. This coefficient K defines the quantity of heat Q transmitted during time T through the walls of pipes having thickness S, and area A for a difference in temperature dt as follows :—

$$K = \frac{Q\ S}{A\ T\ dt}$$

The values of K for temperatures up to 100° C. (212° F.) are as follows :—

	Q	T	S	A	dt	Value of K
Metric units	cal.	hour	m.	sq. m.	1° C.	0.43
British units	B.T.U.	second	in.	sq. in.	1° F.	67×10^{-5}

Thus asbestos-cement is a good insulator.

The average value of K for iron and steel = 0.00075 B.T.U./sec. and is therefore approximately a hundred times greater than for asbestos-cement.

AVERAGE SPECIFIC HEAT. The average specific heat C of " ITALIT " is :—

$$C = 0.23$$

The corresponding figure for cast iron is 0.13 and for steel 0.118.

SHORT SPECIFICATION FOR "ITALIT" ASBESTOS-CEMENT PRESSURE PIPES

COMPOSITION: The pipes shall be composed of an intimate mixture of cement and clean asbestos fibre and formed under pressure on a mandril to provide a dense, homogenous structure with a smooth interior surface. The mixture of cement and asbestos fibre shall contain no grit, or other adulterants, and the finished pipes shall be such that they may be cut, drilled and tapped.

CLASSES AND SIZES: "ITALIT" asbestos-cement pressure pipes shall be made in classes of 200, 400, 600, 800, 1,200, 1,600 feet head test pressure at the factory, and used for working pressures up to one-half of the above test pressures according to the nature and conditions of service and the official regulations of the state where the pipes are used.

"ITALIT" asbestos-cement pressure pipes shall be made in nominal sizes of 1, 1¼, 1½, 2, 2½, 3, 3½, 3¾, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 24, 28, 32, 36, 40 ins. The length of pipe shall be 2, 3, 4, 5 metres (6·56, 9·84, 13·12, 16·40 ft. respectively). Each length shall be clearly and indelibly marked with the Manufacturer's brand, the class, the size, and the date of manufacture.

A tolerance of plus or minus 1 in. shall be allowed on the length of an individual pipe, the total length in any one batch, as shipped, shall not be less than the length ordered.

Five per cent. of any batch may be furnished in lengths shorter than the standard, the minimum lengths being 7 ft.

STANDARD SIMPLEX AND GIBAULT JOINTS: With each length of pipe there shall be supplied one Simplex or one Gibault joint suitable for connecting the lengths of pipe together.

The Simplex joint shall consist of an "ITALIT" sleeve with two rubber rings; the Gibault couplings shall be of cast iron and bituminized, complete with rubber rings and bolts.

HYDRAULIC AND OTHER TESTS: Before despatch, each pipe and joint, shall be subjected, when required by the client, to a hydrostatic pressure equalling the test pressure; each rubber ring shall be stretched to twice its normal diameter and subjected to a visual inspection while in the stretched condition.

FREEDOM FROM DEFECTS: Pipes and joints shall be free from defects and the dimensions shall conform to the manufacturer's tables of dimensions within the stated limits of tolerance.

GUARANTEE: "ITALIT" products found on examination by the Manufacturers to be defective in workmanship or material, as defined by this specification, shall be replaced without charge, within 12 months of delivery date. Such replacement is the limit of the Manufacturers liability on any ground in this connection.

A complete detailed specification is also available and may be had on request.

TABLES OF

DIMENSIONS & WEIGHTS

OF

ITALIT

PRESSURE PIPES

AND

JOINTS & SPECIALS

TABLE

CLASSIFICATION AND DIMENSIONS

PRESSURE

Nominal size	ACTUAL Internal diameter		CLASS **A** Test pressure = 200 ft. head				CLASS **B** Test pressure = 400 ft. head				CLASS **C** Test pressure = 600 ft. head			
			Thickness		External diameter		Thickness		External diameter		Thickness		External diameter	
in.	*mm.*	*in.*	*mm.*	*in.*	*mm.*	*in.*	*mm.*	*in.*	*mm.*	*in.*	*mm.*	*in.*	*mm.*	*in.*
1	25	·98	6	·24	37	1·46								
1¼	32	1·26	7	·28	46	1·81								
1½	40	1·57	8	·32	56	2·20								
2	50	1·97	9	·35	68	2·68					As Class A			
2½	60	2·36	9	·35	78	3·07								
3	70	2·76	9	·35	88	3·46								
3¼	80	3·15	9	·35	98	3·86								
3½	90	3·54	9	·35	108	4·25								
4	100	3·94	9	·35	118	4·65	As Class A				10	·39	120	4·72
5	125	4·92	9	·35	143	5·63					11	·43	147	5·79
6	150	5·91	9	·35	168	6·61					12	·47	174	6·85
7	175	6·89	9	·35	193	7·60					13	·51	201	7·91
8	200	7·87	11	·43	222	8·74					14	·55	228	8·98
9	225	8·86	12	·47	249	9·80					15	·59	255	10·04
10	250	9·84	13	·51	276	10·87					17	·67	284	11·18
12	300	11·81	15	·59	330	12·99					20	·79	340	13·38
14	350	13·78	15	·59	380	14·96					24	·94	398	15·67
16	400	15·75	15	·59	430	16·93	17	·67	434	17·09	28	1·10	456	17·95
18	450	17·72	15	·59	480	18·90	19	·75	488	19·21	31	1·22	512	20·16
20	500	19·69	15	·59	530	20·87	21	·83	542	21·34	34	1·34	568	22·36
24	600	23·62	17	·67	634	24·96	25	·98	650	25·59	40	1·57	680	26·77
28	700	27·56	20	·79	740	29·13	30	1·18	760	29·92	47	1·85	794	31·26
32	800	31·50	22	·87	844	33·23	34	1·34	868	34·17	54	2·13	908	35·75
36	900	35·43	24	·94	948	37·32	38	1·50	976	38·43	60	2·36	1,020	40·16
40	1,000	39·37	27	1·06	1,054	41·50	42	1·65	1,084	42·68	66	2·60	1,132	44·57

NOTE.—The working pressure shoul

VIII

OF "ITALIT" ASBESTOS-CEMENT

PIPES

Standard length of pipe	CLASS D Test pressure = 800 ft. head				CLASS E Test pressure = 1,200 ft. head				CLASS F Test pressure = 1,600 ft. head				Nominal size
	Thickness		External diameter		Thickness		External diameter		Thickness		External diameter		
m.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	in.
Two or Three	As Class A				As Class A				6	·24	37	1·46	1
									7	·28	46	1·81	1¼
									8	·32	56	2·20	1½
Three									10	·39	70	2·76	2
									10	·39	80	3·15	2½
									12	·47	94	3·70	3
					11	·43	102	4·02	14	·55	108	4·25	3¼
					12	·47	114	4·49	15	·59	120	4·72	3½
Four	10	·39	120	4·72	14	·55	128	5·04	17	·67	134	5·28	4
	13	·51	151	5·94	17	·67	159	6·26	21	·83	167	6·57	5
	15	·59	180	7·09	20	·79	190	7·48	25	·98	200	7·87	6
	18	·71	211	8·31	24	·94	223	8·78	30	1·18	235	9·25	7
Four or Five	20	·79	240	9·45	27	1·06	254	10·00	34	1·34	268	10·55	8
	23	·91	271	10·67	30	1·18	285	11·22	38	1·50	301	11·85	9
	25	·98	300	11·81	34	1·34	318	12·52	42	1·65	334	13·15	10
	30	1·18	360	14·17	40	1·57	380	14·96	50	1·97	400	15·75	12
Five	35	1·38	420	16·54	—	—	—	—	—	—	—	—	14
	40	1·57	480	18·90	—	—	—	—	—	—	—	—	16
	45	1·77	540	21·26	—	—	—	—	—	—	—	—	18
	50	1·97	600	23·62	—	—	—	—	—	—	—	—	20
	60	2·36	720	28·35	—	—	—	—	—	—	—	—	24
	—	—	—	—	—	—	—	—	—	—	—	—	28
	—	—	—	—	—	—	—	—	—	—	—	—	32
	—	—	—	—	—	—	—	—	—	—	—	—	36
	—	—	—	—	—	—	—	—	—	—	—	—	40

not exceed one half the test pressure.

TABLE IX

WEIGHTS OF "ITALIT" ASBESTOS-CEMENT

PRESSURE PIPES

In kilos and pounds per metre

Nominal size ins.	CLASS A		CLASS B		CLASS C		CLASS D		CLASS E		CLASS F		Nominal size ins.
	kg.	lb.	kg.	lb.	kg.	lb.	kg.	lb.	kg.	lb.	kg.	lb.	
1	1·3	2·9									1·3	2·9	1
1¼	1·9	4·2									1·9	4·2	1¼
1½	2·6	5·8							As Class A		2·6	5·8	1½
2	3·6	8·0			As Class A						4·0	8·8	2
2½	4·2	9·3									4·7	10·4	2½
3	4·8	10·6							—	—	6·5	14·3	3
3¼	5·4	11·9							6·6	14·6	8·7	19·2	3¼
3½	6·0	13·2							8·0	17·7	10·4	23·0	3½
4	6·5	14·3	As Class A		7·5	16·5	7·5	16·5	10·6	23·4	13·2	29·1	4
5	8·5	18·8			10·0	22·0	12·0	26·5	16·0	35·3	20·0	44·1	5
6	10·0	22·0			13·3	29·3	16·7	36·8	22·5	49·6	29·0	64·0	6
7	12·0	26·5			16·5	36·4	23·0	50·7	31·5	69·5	40·0	88·2	7
8	16·0	35·3			20·0	44·1	29·0	64·0	40·0	88·2	52·0	114·7	8
9	19·0	41·9			24·0	53·0	37·5	83·0	50·0	111·0	65·0	144·0	9
10	23·0	50·7			30·0	66·2	45·0	99·2	63·0	139·0	79·0	175·0	10
12	32·0	70·6			42·0	92·6	64·5	142·2	88·0	194·0	113·0	250·0	12
14	37·0	81·6			59·0	130·1	87·0	192·0	—	—	—	—	14
16	42·0	92·6	47·0	103·6	78·0	172·0	114·0	251·5	—	—	—	—	16
18	48·0	106·0	60·5	133·5	98·5	217·2	144·0	317·5	—	—	—	—	18
20	53·5	118·0	74·0	163·2	119·0	262·5	179·0	395·0	—	—	—	—	20
24	74·0	163·0	106·0	234·0	169·0	373·0	258·0	569·0	—	—	—	—	24
28	100·0	225·0	147·0	324·0	231·0	510·0	—	—	—	—	—	—	28
32	124·0	274·0	189·0	417·0	301·0	664·0	—	—	—	—	—	—	32
36	151·0	333·0	236·0	521·0	374·0	825·0	—	—	—	—	—	—	36
40	187·0	413·0	289·0	638·0	456·0	1006·0	—	—	—	—	—	—	40

NOTE.—A tolerance of approximately 10 per cent. is allowed on these weights.

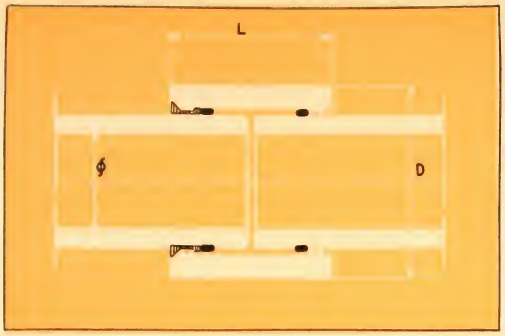


TABLE X

DIMENSIONS AND WEIGHTS OF

SIMPLEX JOINTS

(Inclusive of Rubber Rings)

Nominal size of pipe	Length "L" of sleeve common to all classes		CLASS **A**			CLASS **B**			CLASS **C**			CLASS **D**			Nominal size of pipe
			Outside diameter D		Weight	Outside diameter D		Weight	Outside diameter D		Weight	Outside diameter D		Weight	
ins.	mm.	ins.	mm.	ins.	kg.	mm.	ins.	kg.	mm.	ins.	kg.	mm.	ins.	kg.	ins.
1	100	3·94	67	2·64	·45										1
1¼	100	3·94	76	2·99	·50										1¼
1½	100	4·94	88	3·47	·65										1½
2	150	5·90	106	4·17	1·35				As Class A			As Class A			2
2½	150	5·90	116	4·57	1·45										2½
3	150	5·90	126	4·96	1·60										3
3¼	150	5·90	136	5·35	1·75										3¼
3½	150	5·90	148	5·83	2·00										3½
4	150	5·90	160	6·30	2·25				164	6·46	2·40	164	6·46	2·45	4
5	150	5·90	185	7·28	2·65	As Class A			193	7·60	2·45	199	7·83	3·30	5
6	150	5·90	210	8·27	3·00				222	8·74	3·00	234	9·21	4·40	6
7	150	5·90	235	9·25	3·50				251	9·88	3·80	271	10·67	6·00	7
8	150	5·90	268	10·55	4·45				280	11·02	4·50	306	12·05	7·55	8
9	150	5·90	297	11·69	5·20				309	12·17	5·30	343	13·50	9·00	9
10	150	5·90	326	12·84	5·60				342	13·46	6·20	378	14·88	11·20	10
12	180	7·09	381	15·00	8·70				409	16·10	7·45	453	17·84	19·20	12
14	180	7·09	435	17·13	10·30				477	18·78	12·50	527	20·75	26·00	14
16	180	7·09	483	18·02	11·00	493	19·41	12·80	545	21·46	17·00	599	23·58	34·00	16
18	180	7·09	533	20·98	12·50	551	21·69	15·60	607	23·90	22·40	671	26·42	42·00	18
20	180	7·09	583	22·95	13·80	611	24·06	19·00	674	26·54	27·30	—	—	—	20
24	200	7·87	694	27·32	20·50	732	28·82	31·00	802	31·57	33·50	—	—	—	24
28	200	7·87	806	31·73	26·50	852	33·54	41·50	932	36·69	50·00	—	—	—	28
32	200	7·87	916	36·06	34·00	970	38·19	52·00	—	—	—	—	—	—	32
36	200	7·87	1,024	40·32	40·00	1,088	42·84	66·00	—	—	—	—	—	—	36
40	200	7·87	1,136	44·73	49·00	1,206	47·48	80·00	—	—	—	—	—	—	40

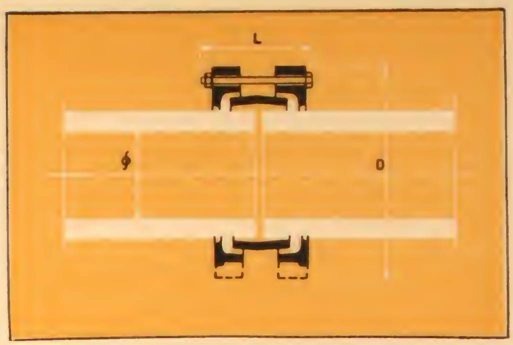
NOTE.—A tolerance of approximately 10 per cent. is allowed on these weights.

TABLE XI

DIMENSIONS AND WEIGHTS OF THE

GIBAULT DETACHABLE JOINTS

(Inclusive of Bolts, Nuts and Rubber Rings)



Nominal size of pipe	CLASS A			CLASS B			CLASS C			CLASS D			CLASS E			CLASS F			Nominal size of pipe
	D	L	Weight	D	L	Weight	D	L	Weight	D	L	Weight	D	L	Weight	D	L	Weight	
ins.	ins.	ins.	kg.	ins.	ins.	kg.	ins.	ins.	kg.	ins.	ins.	kg.	ins.	ins.	kg.	ins.	ins.	kg.	ins.
1	2·44	2·36	·49													2·44	2·36	·49	1
1¼	2·76	2·36	·59													2·76	2·36	·59	1¼
1½	3·31	2·76	1·06										As Class A			3·31	2·76	1·06	1½
2	3·94	3·54	1·61				As Class A			As Class A						4·09	3·54	1·76	2
2½	4·33	3·54	1·87													4·49	3·54	2·07	2½
3	4·72	3·54	1·92													5·24	3·54	2·49	3
3¼	5·12	3·54	2·18										5·51	3·54	2·62	5·87	3·54	3·10	3¼
3½	5·51	3·54	2·28										6·06	3·54	3·06	6·34	3·54	3·31	3½
4	6·14	3·94	3·14	As Class A			6·28	3·94	3·84	6·28	3·94	3·84	6·81	4·33	4·37	7·36	4·33	6·21	4
5	7·13	3·94	4·35				7·30	4·33	5·01	7·72	4·33	6·05	8·11	4·33	6·43	8·74	4·72	8·07	5
6	8·19	3·94	5·24				8·56	4·33	6·28	8·94	4·33	7·30	9·57	4·72	8·68	10·10	4·72	9·48	6
7	9·25	3·94	6·22				9·61	4·33	7·15	10·20	4·33	8·41	10·90	4·72	10·40	11·40	4·72	11·50	7
8	10·50	4·33	7·85				10·80	4·33	8·65	11·40	4·33	10·10	12·20	4·72	12·70	13·10	5·51	16·60	8
9	11·50	4·72	8·77				11·90	4·72	9·92	12·80	5·12	14·10	13·50	5·12	15·10	14·40	5·51	18·80	9
10	12·80	4·72	13·10				13·20	4·72	14·00	13·90	5·12	16·20	15·10	5·51	19·70	15·70	5·51	21·80	10
12	15·10	5·12	16·90				15·60	5·12	18·00	16·40	5·12	20·20	17·6	5·51	24·20	18·40	5·91	27·20	12
14	17·20	5·51	21·20				18·40	5·51	27·80	19·20	5·51	29·80	—	—	—	—	—	—	14
16	19·30	5·51	24·70	19·4	5·51	25·7	20·60	6·30	33·10	21·70	6·30	37·10	—	—	—	—	—	—	16
18	21·60	6·30	35·10	21·9	6·30	35·6	22·90	6·30	39·20	24·10	6·30	44·20	—	—	—	—	—	—	18
20	23·50	6·30	38·20	24·0	6·30	40·2	25·50	6·69	55·60	27·00	7·09	65·70	—	—	—	—	—	—	20
24	27·70	6·69	51·00	28·4	6·69	54·0	30·00	7·09	78·00	31·60	7·48	89·20	—	—	—	—	—	—	24
28	32·20	7·48	74·60	33·1	7·48	80·6	34·40	7·87	96·50	—	—	—	—	—	—	—	—	—	28
32	36·40	7·87	95·00	37·4	7·87	102·0	39·50	8·66	136·10	—	—	—	—	—	—	—	—	—	32
36	40·60	7·87	114·20	41·8	7·87	124·3	43·90	9·05	160·30	—	—	—	—	—	—	—	—	—	36
40	44·80	8·27	128·40	46·0	8·27	146·4	48·40	9·45	185·50	—	—	—	—	—	—	—	—	—	40

NOTE.—A tolerance of approximately 10 per cent. is allowed on these weights.

NUMBER OF BOLTS PER JOINT

Nominal size of pipe ins.	1–1¼	1½–7	8–12	14–20	24–28	32	36	40
Number of Bolts per joint	2	3	4	6	8	10	12	14

TABLE XII

"ITALIT" ASBESTOS-CEMENT **PRESSURE BENDS**

Class, Dimensions and Weights

Nominal size	All Angles Length "L"		30° Bend			45° Bend			60° Bend			90° Bend			Weight	Nominal size
			Class	Radius		Class	Radius		Class	Radius		Class	Radius			
ins.	m.	ft. ins.		m.	ft. ins.		m.	ft. ins.		m.	ft. ins.		m.	ft. ins.	kg.	ins.
1	1·0	3 3	A–D	1·53	5 0	A–D	1·00	3 3	A–C	·80	2 7	A–C	·51	1 8	1·3	1
1¼	1·0	3 3	A–D	1·53	5 0	A–D	1·00	3 3	A–C	·80	2 7	A–C	·51	1 8	1·9	1¼
1½	1·0	3 3	A–D	1·53	5 0	A–D	1·00	3 3	A–C	·80	2 7	A–C	·51	1 8	2·6	1½
2	1·5	4 11	A–D	2·48	8 2	A–D	1·66	5 5	A–C	1·24	4 1	A–C	·83	2 9	5·4	2
2½	1·5	4 11	A–D	2·48	8 2	A–C	1·66	5 5	A–B	1·24	4 1	A–B	·83	2 9	6·3	2½
3	1·5	4 11	A–C	2·48	8 2	A–C	1·66	5 5	A–B	1·24	4 1	A–B	·83	2 9	7·2	3
3½	1·5	4 11	A–C	2·48	8 2	A–C	1·66	5 5	A–B	1·24	4 1	A–B	·83	2 9	8·1	3½
4	2·0	6 7	A–B	3·44	11 3	A–B	2·29	7 6	A–B	1·72	5 8	A–B	1·15	3 9	13·0	4
			C	3·44	11 3	C	2·29	7 6	C	1·72	5 8	C	1·15	3 9	15·0	
5	2·0	6 7	A–B	3·44	11 3	A–B	2·29	7 6	A–B	1·72	5 8	—	—	—	17·0	5
			C	3·44	11 3	C	2·29	7 6	—	—	—	—	—	—	20·0	
6	2·0	6 7	A–B	3·44	11 3	A–B	2·29	7 6	A	1·72	5 8	—	—	—	20·0	6
7	2·0	6 7	A	3·44	11 3	A	2·29	7 6	—	—	—	—	—	—	24·0	7
8	2·0	6 7	A	3·44	11 3	A	2·29	7 6	—	—	—	—	—	—	32·0	8

N.B. The actual internal diameter of the bends is the same as that of straight pipes.

A tolerance of approximately 10 per cent. is allowed on these weights.

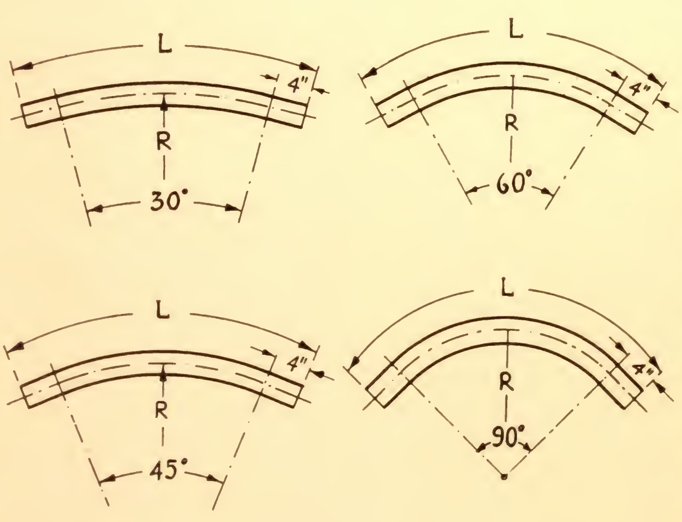


FIG. 33.—45° "ITALIT" PRESSURE BENDS CONNECTED WITH GIBAULT JOINTS

TABLE XIII

DIMENSIONS OF

CAST IRON SPECIAL PIECES

FOR "ITALIT" PIPES

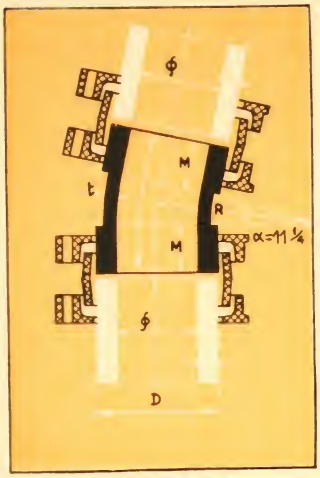
(In British units)

Nominal size of pipe	Actual internal diameter		Dimensions for all classes					CLASS A		CLASS B		CLASS C		CLASS D		CLASS E		CLASS F		Nominal size of pipe
			R	A	B	M	N	D	t	D	t	D	t	D	t	D	t	D	t	
ins.	mm.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
1	25	·98	1·18	2·76	3·15	1·97	3·94	1·46	·16									1·46	·16	1
1¼	32	1·26	1·57	2·95	3·54	1·97	3·94	1·81	·16									1·81	·16	1¼
1½	40	1·57	1·89	3·15	3·94	1·97	3·94	2·20	·16							As Class		2·20	·16	1½
2	50	1·97	9·84	5·71	6·89	3·94	3·94	2·68	·31			As Class A		As Class A		A		2·76	·31	2
2½	60	2·36	10·24	5·91	7·09	3·94	3·94	3·07	·31									3·15	·31	2½
3	70	2·76	10·63	6·10	7·28	3·94	3·94	3·46	·31									3·70	·35	3
3¼	80	3·15	11·02	6·30	7·48	3·94	3·94	3·86	·31							4·02	·35	4·25	·39	3¼
3½	90	3·54	11·42	6·69	7·68	3·94	3·94	4·25	·31							4·49	·35	4·72	·39	3½
4	100	3·94	11·81	7·09	7·87	3·94	3·94	4·65	·31	As Class		4·72	·35	4·72	·35	5·04	·39	5·28	·43	4
5	125	4·92	12·80	7·48	8·39	3·94	3·94	5·63	·35	A		5·79	·35	5·94	·39	6·26	·43	6·57	·47	5
6	150	5·91	13·78	7·87	8·86	3·94	3·94	6·61	·35			6·85	·39	7·09	·43	7·48	·47	7·87	·51	6
7	175	6·89	14·76	8·46	8·98	3·94	3·94	7·60	·35			7·91	·43	8·31	·47	8·78	·55	9·25	·63	7
8	200	7·87	15·75	8·86	9·84	3·94	3·94	8·74	·39			8·98	·47	9·45	·51	10·00	·59	10·55	·67	8
9	225	8·86	16·73	9·45	10·35	3·94	3·94	9·80	·39			10·04	·47	10·67	·55	11·22	·63	11·85	·71	9
10	250	9·84	17·72	9·84	11·81	3·94	3·94	10·87	·43			11·18	·51	11·81	·59	12·52	·67	13·15	·79	10
12	300	11·81	19·69	10·83	12·80	3·94	3·94	13·00	·51			13·39	·59	14·17	·67	14·96	·79	15·75	·91	12
14	350	13·78	21·65	11·81	13·78	3·94	7·87	14·96	·51	14·96	·59	15·67	·67	16·54	·71	—	—	—	—	14
16	400	15·75	23·62	12·80	14·76	3·94	7·87	16·93	·51	17·09	·63	17·95	·71	18·90	·78	—	—	—	—	16
18	450	17·72	25·60	13·78	15·75	3·94	7·87	18·90	·51	19·21	·63	20·16	·75	21·26	·87	—	—	—	—	18
20	500	19·69	27·56	15·75	17·72	3·94	7·87	20·87	·55	21·34	·67	22·36	·79	23·62	·98	—	—	—	—	20
24	600	23·62	31·50	17·72	19·69	3·94	7·87	24·96	·63	25·59	·75	26·77	·87	28·35	1·14	—	—	—	—	24
28	700	27·56	35·43	19·69	21·65	3·94	7·87	29·13	·67	29·92	·79	31·26	·90	—	—	—	—	—	—	28
32	800	31·50	39·37	22·05	23·62	3·94	7·87	33·23	·71	34·17	·83	35·75	1·02	—	—	—	—	—	—	32
36	900	35·43	43·31	22·41	25·60	3·94	7·87	37·32	·75	38·43	·87	40·16	1·10	—	—	—	—	—	—	36
40	1000	39·37	47·24	26·77	27·56	3·94	7·87	41·50	·79	42·68	·90	44·57	1·18	—	—	—	—	—	—	40

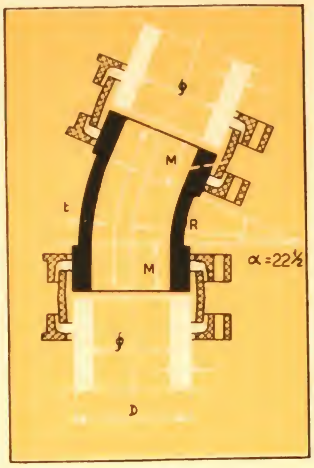
NOTE.—For the dimensions of Flanges see table XV.

CAST IRON SPECIALS

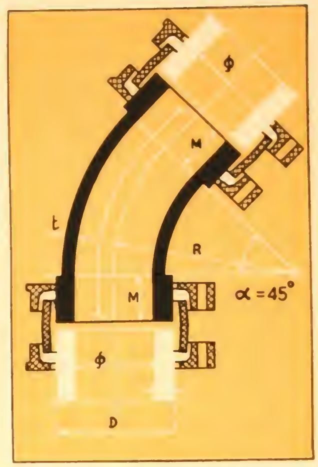
FOR "ITALIT" ASBESTOS-CEMENT PRESSURE PIPES



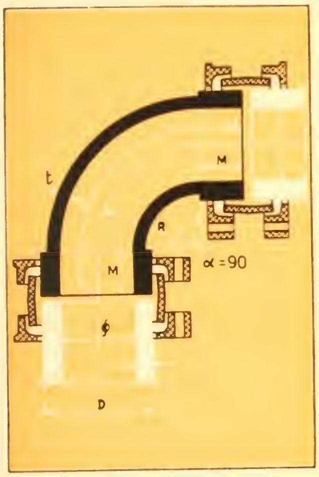
1. 11¼° BEND



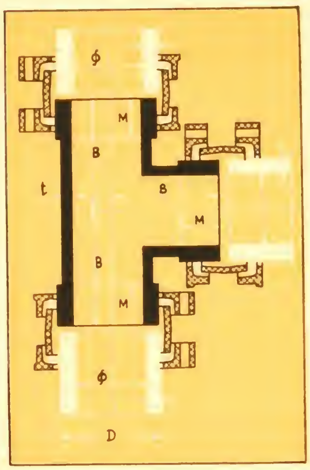
2. 22½° BEND



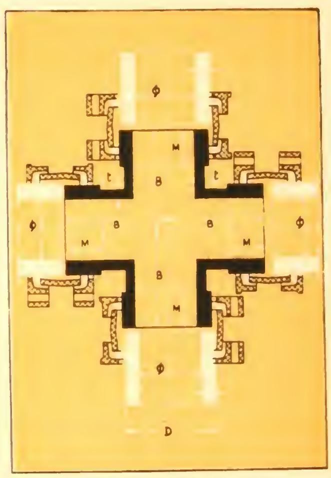
3. 45° BEND



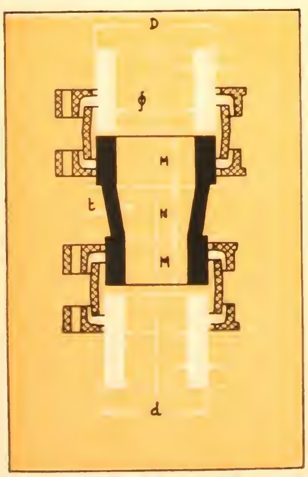
4. 90° BEND



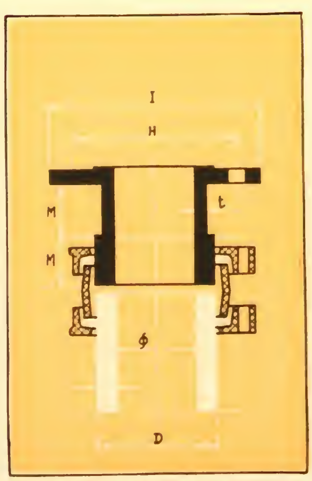
5. EQUAL TEE



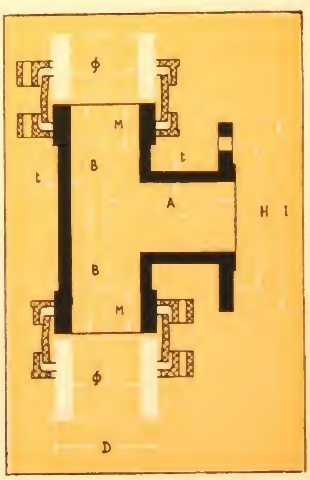
6. CROSS PIECE



7. REDUCER



8. FLANGE ADAPTOR



9. HYDRANT TEE

TABLE XIV

DIMENSIONS OF

CAST IRON SPECIAL PIECES

FOR "ITALIT" PIPES

(In Metric units)

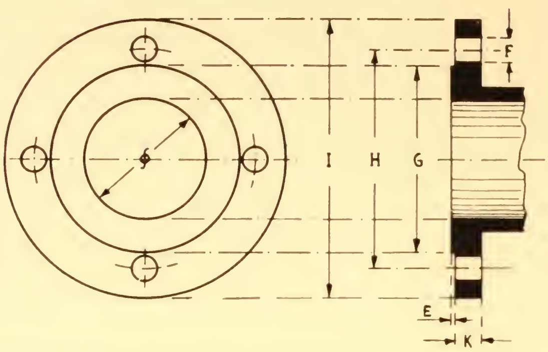
Nominal size of pipe	Actual internal diameter		Dimensions for all Classes					CLASS **A**		CLASS **B**		CLASS **C**		CLASS **D**		CLASS **E**		CLASS **F**		Nominal size of pipe
			R	A	B	M	N	D	t	D	t	D	t	D	t	D	t	D	t	
ins.	mm.	ins.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	ins.
1	25	·98	30	70	80	50	100	37	4									37	4	1
1¼	32	1·26	40	75	90	50	100	46	4									46	4	1¼
1½	40	1·57	48	80	100	50	100	56	4									56	4	1½
2	50	1·97	250	145	175	100	100	68	8							As Class A		70	8	2
2½	60	2·36	260	150	180	100	100	78	8			As Class A						80	8	2½
3	70	2·76	270	155	185	100	100	88	8									94	9	3
3¼	80	3·15	280	160	190	100	100	98	8							102	9	108	10	3¼
3½	90	3·54	290	170	195	100	100	108	8							114	9	120	10	3½
4	100	3·94	300	180	200	100	100	118	8	As Class A		120	9	120	9	128	10	134	11	4
5	125	4·92	325	190	213	100	100	143	9			147	9	151	10	159	11	167	12	5
6	150	5·91	350	200	225	100	100	168	9			174	10	180	11	190	12	200	13	6
7	175	6·89	375	215	228	100	100	193	9			201	11	211	12	223	14	235	16	7
8	200	7·87	400	225	250	100	100	222	10			228	12	240	13	254	15	268	17	8
9	225	8·86	425	240	263	100	100	249	10			255	12	271	14	285	16	301	18	9
10	250	9·84	450	250	300	100	100	276	11			284	13	300	15	318	17	334	20	10
12	300	11·81	500	275	325	100	100	330	13			340	15	360	17	380	20	400	23	12
14	350	13·78	550	300	350	100	200	380	13	380	15	398	17	420	19	—	—	—	—	14
16	400	15·75	600	325	375	100	200	430	13	434	16	456	18	480	20	—	—	—	—	16
18	450	17·72	650	350	400	100	200	480	13	488	16	512	19	540	22	—	—	—	—	18
20	500	19·69	700	400	450	100	200	530	14	542	17	568	20	600	25	—	—	—	—	20
24	600	23·62	800	450	500	100	200	634	16	650	19	680	22	720	29	—	—	—	—	24
28	700	27·56	900	500	550	100	200	740	17	760	20	794	23	—	—	—	—	—	—	28
32	800	31·50	1,000	560	600	100	200	844	18	868	21	908	26	—	—	—	—	—	—	32
36	900	35·43	1,100	620	650	100	200	948	19	976	22	1,020	28	—	—	—	—	—	—	36
40	1,000	39·37	1,200	680	700	100	200	1,054	20	1,084	23	1,132	30	—	—	—	—	—	—	40

NOTE.—For the dimensions of Flanges, see table XV.

TABLE XV

DIMENSIONS OF **FLANGES** FOR CAST IRON FITTINGS FOR "ITALIT" PIPES

(International Pattern)



Nominal size of pipe	Actual internal diameter		G		H (Diameter of bolt circle)		I (Diameter of flange)		F (Diameter of bolts)		K (Thickness of flange)		E		Bolt holes	Nominal size of pipe
ins.	mm.	ins.	mm.	ins.	mm.	ins.	mm.	ins.	mm.	ins.	mm.	ins.	mm.	ins.	No.	ins.
1	25	·98	65	2·56	80	3·15	110	4·33	14	·55	13	·51	2	·08	4	1
1¼	32	1·26	72	2·83	95	3·74	125	4·92	14	·55	15	·59	2	·08	4	1¼
1½	40	1·57	90	3·54	110	4·33	140	5·51	14	·55	17	·67	3	·12	4	1½
2	50	1·97	100	3·94	125	4·92	160	6·30	18	·71	18	·71	3	·12	4	2
2½	60	2·36	110	4·33	135	5·31	175	6·89	18	·71	19	·75	3	·12	4	2½
3	70	2·76	120	4·72	145	5·71	185	7·28	18	·71	19	·75	3	·12	4	3
3¼	80	3·15	130	5·12	160	6·30	200	7·87	18	·71	20	·79	3	·12	4	3¼
3½	90	3·54	140	5·51	170	6·69	215	8·46	18	·71	20	·79	3	·12	4	3½
4	100	3·94	156	6·14	180	7·09	230	9·06	21	·83	20	·79	3	·12	4	4
5	125	4·92	181	7·13	210	8·27	260	10·24	21	·83	21	·83	3	·12	4	5
6	150	5·91	206	8·11	240	9·45	290	11·42	21	·83	22	·87	3	·12	6	6
7	175	6·89	235	9·25	270	10·63	320	12·60	21	·83	22	·87	3	·12	6	7
8	200	7·87	260	10·24	300	11·81	350	13·78	21	·83	23	·91	3	·12	6	8
9	225	8·86	285	11·22	320	12·60	370	14·57	21	·83	23	·91	3	·12	6	9
10	250	9·84	310	12·20	350	13·78	400	15·75	21	·83	24	·94	3	·12	8	10
12	300	11·81	360	14·17	400	15·75	450	17·72	21	·83	25	·98	3	·12	8	12
14	350	13·78	420	16·54	465	18·31	520	20·47	25	·98	26	1·02	4	·16	10	14
16	400	15·75	470	18·50	520	20·47	575	22·64	25	·98	27	1·06	4	·16	10	16
18	450	17·72	520	20·47	570	22·44	630	24·80	25	·98	28	1·10	4	·16	12	18
20	500	19·69	580	22·83	625	24·61	680	26·77	25	·98	30	1·18	4	·16	12	20
24	600	23·62	680	26·77	725	28·54	790	31·10	28	1·10	33	1·30	5	·20	16	24
28	700	27·56	780	30·71	830	32·68	900	35·43	28	1·10	33	1·30	5	·20	18	28
32	800	31·50	880	34·65	940	37·01	1,020	40·15	32	1·26	36	1·42	5	·20	20	32
36	900	35·43	990	38·98	1,040	40·94	1,120	44·09	32	1·26	36	1·42	5	·20	22	36
40	1,000	39·37	1,090	42·91	1,140	44·88	1,220	48·03	32	1·26	36	1·42	5	·20	24	40

NOTE.—Undrilled Flanges, or Flanges drilled to B.S. can be supplied on request.

FIG. 34.—"ITALIT" LOW PRESSURE PIPES 12 IN. (300 MM.) DIA.
IN SEWERAGE SCHEME

ASBESTOS-CEMENT

LOW PRESSURE

(SEWER) PIPES

"ITALIT" SEWER PIPES IN USE

1. CLASS A PRESSURE PIPES WITH SIMPLEX JOINT IN SEWERAGE SCHEME
2. 12 IN. (300 MM.) DIA. PIPES DEEP LAID NEAR BARI (ITALY)
3. SAN REMO 18 IN. (450 MM.) DIA. LOW PRESSURE PIPES FOR SEWERAGE SHOWING PORTION LAID ALONG THE SHORE IN THE CLIFF FACE
4. PIPES FOR THE SAN REMO SCHEME BEFORE LAYING

"ITALIT" ASBESTOS-CEMENT LOW PRESSURE (SEWER) PIPES

THE PROBLEM OF SEWAGE DISPOSAL

THE rapid development of communities at home and in the colonies, increases the need for efficient methods in the disposal of sewage, and industrial and surface waters.

It is estimated that in the most advanced countries the average amount of domestic and industrial sewage for disposal is 100 gallons per person, per day ; this multiplied by the total population gives colossal figures per year. To this surface waters must be added, which increase in quantity from time to time during wet periods. The disposal of sewage is therefore as important to communities as the supply of drinking water, and is a matter of much concern to Public Sanitary Authorities.

During the last decade important advances have been made in the handling, disposal and purification of sewage by improved methods, materials, and plants, which have lead to greater efficiency and a rise in the standard of health.

For the conveyance of sewage, various types of pipes have been adopted, e.g. glazed earthenware, cast iron, steel, and concrete.

After the asbestos-cement pipe began to be used with outstanding success for water mains, engineers and sanitary authorities especially in America and on the Continent of Europe, were quick to realize the many advantages of this new pipe over those previously used in sewers. In the U.S.A. and Canada these pipes are now being used for this purpose in ever increasing quantities.

In Italy, the country where the asbestos-cement pipe originated, the first sewers employing asbestos-cement pipes, were laid in the twenties; following this their demand for use in gravity sewers continually increased, so it was thought advisable to manufacture a special light pipe provided with socket for this purpose, as distinct from the pressure pipes which would then be used for uprising sewer mains. This lighter pipe which is also suitable for soil, drainage, as well as cable conduits, is marketed under the name of Low Pressure or Sewer pipe.

ADVANTAGES OF THE ASBESTOS-CEMENT LOW PRESSURE PIPE

THESE pipes are made in exactly the same way as pressure pipes, by spinning a layer of an intimate mixture of Portland cement, and asbestos fibre by the well-known Mazza process, which has been adopted throughout the world and recognised as the most efficient method of manufacturing asbestos-cement pipes.

" ITALIT " low pressure pipes therefore, possess all the well known advantages already numbered in the previous chapters dealing with pressure pipes, namely durability, impermeability, immunity from corrosion and tuberculation, light weight, smoothness of bore, etc.

They have, however, some specific advantages over glazed earthenware pipes, which can be summarized as follows :

(1) HIGHER RESISTANCE to internal and external pressure and all the various stresses which pipes may have to sustain.

(2) FEWER JOINTS. As " ITALIT " pipes are available in lengths up to 5 m. (16.40 ft.,) fewer joints are required than with earthenware and other non-metallic pipes, resulting in economy, speed of laying and safer service.

(3) EASIER TO WORK. " ITALIT " low pressure pipes can easily be cut, drilled and tapped with ordinary tools, thus eliminating material and labour wastage.

(4) MORE ECONOMICAL. By using " ITALIT " low pressure pipes initial and operational saving are realized for the following reasons : lower cost, lower freight and transport, cheaper laying and jointing, longer life.

DESCRIPTION OF "ITALIT" LOW PRESSURE PIPES

" ITALIT " low pressure pipes are usually supplied with monolithic or applied sockets at one end, the joint being made with tarred tow and cement mortar or with bituminous mastic.

For conduit purposes plain ended pipes are supplied complete with an asbestos-cement sleeve and two rubber rings for jointing. The low pressure pipes are made in one class only and tested at the following hydraulic pressure :—

DIAMETER in.	up to 10	12	14	16	18—20
FEET HEAD	66	56	53	50	46

Their average breaking stress caused by internal hydraulic pressure equals 1,700 lb./sq. in. (120 kg./cm.^{2}).

They can be safely laid in the ground at the depths given by the graph on page 49.

In the case of large diameter pipes requiring deep laying a verification of stability is recommended, and the use of one of the various classes of pressure pipes may be necessary.

" ITALIT " low pressure pipes are manufactured in the same diameters as the pressure pipes, ranging from 1 to 20 nominal ins. (see table on page 81).

The standard lengths and types of socket are as follows :—

Nominal size of pipe ins.	*Standard length m.*	*ft.*	*Standard type of socket*
1— 1½	2	6·56	Monolithic or applied socket.
2—12	3	9·84	Monolithic or applied socket.
14—20	4	13·12	Applied socket.

Pipes up to 12 ins. can also be supplied in the following non-standard lengths : .50, 1.0, 1.50, 2.50 m. (1.64, 3.28, 4.92, 8.20 ft.). A full range of asbestos-cement special pieces is available for use with " ITALIT " low pressure pipes as shown on page 80.

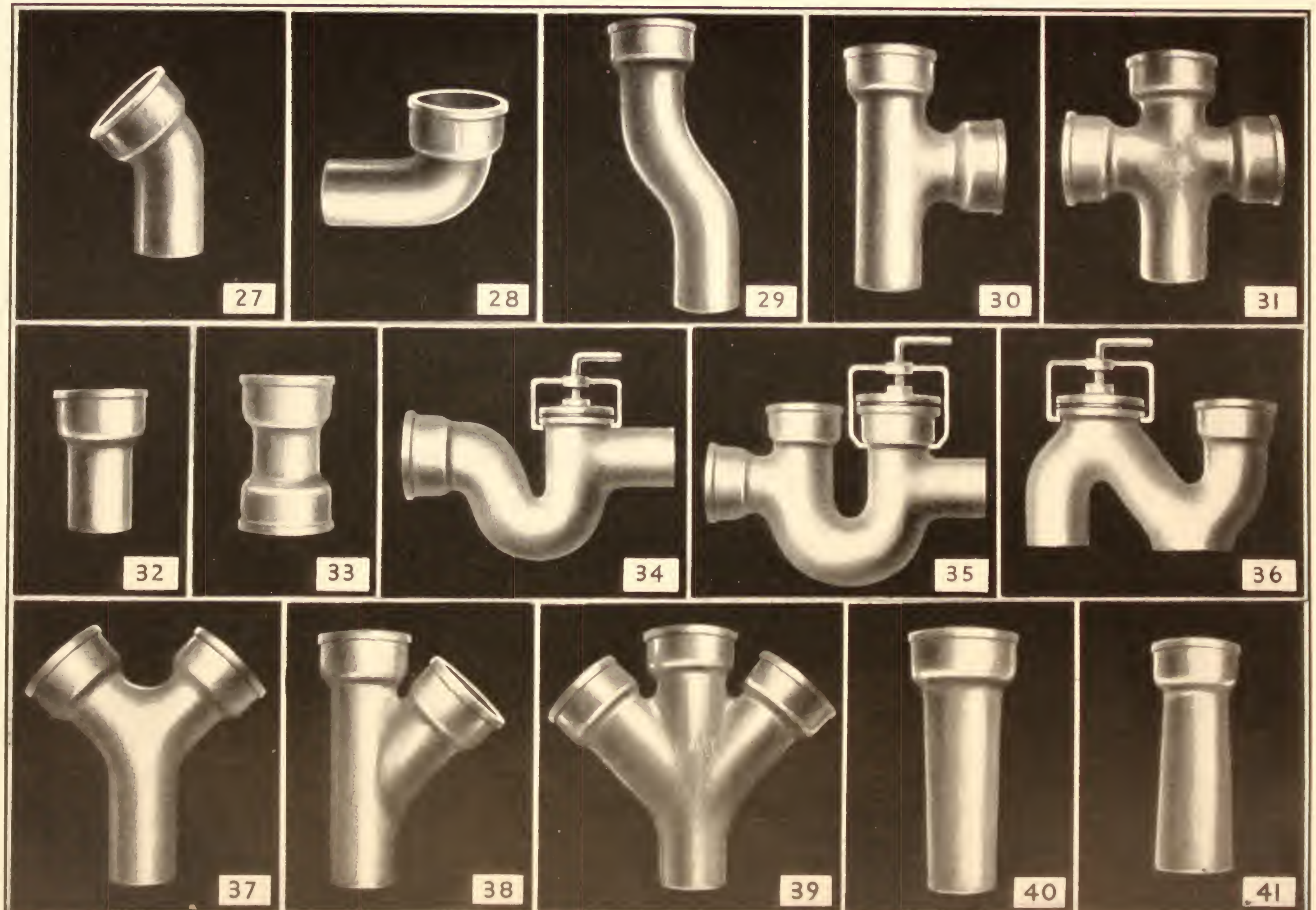
These specials are stocked only in diameters up to 12 ins. ; specials of larger diameters and with inspection doors, can be made on request.

Tee, cross and branch pieces can be supplied with branches of smaller diameter than that of the conduit.

NOTE.—" ITALIT " *low pressure pipes are made in larger diameters and have a wider field of employment than the* " *Soil Pipes* " *as described in B.S.* 582—1948. *However, all guarantees and testing methods laid down in these Specifications are applicable to* " ITALIT " *low pressure pipes.*

FIG. 35.—ASBESTOS-CEMENT LINING, OVATE SECTION FOR LARGE CONCRETE SEWER MAINS.

SPECIAL PIECES FOR "ITALIT" ASBESTOS-CEMENT LOW PRESSURE PIPES



27. 45° BEND
28. 90° BEND
29. PARALLEL
30. TEE PIECE
31. CROSS PIECE
32. CONNECTOR SINGLE SOCKET
33. CONNECTOR DOUBLE SOCKET
34. RUNNING TRAP
35. DRAIN TRAP
36. FULL "S" TRAP
37. "Y" PIECE
38. 45° SINGLE BRANCH
39. 45° DOUBLE BRANCH
40. REDUCER TYPE A
41. REDUCER TYPE B

TABLE XVI

DIMENSIONS AND WEIGHTS OF "ITALIT" ASBESTOS-CEMENT

LOW PRESSURE PIPES

Complete with Applied Socket

Nominal size	Actual internal diameter		Thickness		Weight in kilos per pipe inclusive of socket								Weight per metre excluding socket
					Length ·25 m.	Length ·50 m.	Length 1 m.	Length 1·50 m.	Length 2 m.	Length 2·5 m.	Length 3 m.	Length 4 m.	
ins.	mm.	ins.	mm.	ins.	(·82 ft.)	(1·64 ft.)	(3·28 ft.)	(4·92 ft.)	(6·56 ft.)	(8·20 ft.)	(9·84 ft.)	(13·12 ft.)	kg.
1	25	·98	4·0	·16	0·36	0·51	0·81	1·11	1·41	—	—	—	0·60
1¼	32	1·26	4·0	·16	0·51	0·71	1·11	1·51	1·91	—	—	—	0·80
1½	40	1·57	4·5	·18	0·61	0·88	1·43	1·98	2·53	—	—	—	1·10
2	50	1·97	5·0	·20	0·87	1·29	2·14	2·99	3·84	4·69	5·54	—	1·70
2½	60	2·36	6·0	·24	1·16	1·77	3·00	4·23	5·45	6·68	7·90	—	2·45
3¼	80	3·15	7·0	·28	1·65	2·62	4·54	6·47	8·39	10·32	12·24	—	3·85
4	100	3·94	8·0	·32	2·10	3·27	5·62	7·97	10·32	12·67	15·02	—	4·70
5	125	4·92	9·0	·35	3·17	4·89	8·34	11·79	15·24	18·69	22·14	—	6·90
6	150	5·91	9·0	·35	3·80	5·90	10·10	14·30	18·50	22·70	26·90	—	8·40
7	175	6·89	9·0	·35	4·45	6·70	11·20	15·70	20·20	24·70	29·20	—	9·00
8	200	7·87	9·0	·35	5·46	8·32	14·00	19·68	25·35	31·03	36·70	—	11·35
10	250	9·84	10·0	·39	6·95	10·60	17·90	25·20	32·50	39·80	47·10	—	14·60
12	300	11·81	10·0	·39	8·90	13·60	23·00	32·40	41·80	51·20	60·60	—	18·80
14	350	13·78	10·0	·39	—	—	—	—	—	—	—	95·05	22·40
16	400	15·75	12·0	·47	—	—	—	—	—	—	—	118·40	27·90
18	450	17·72	12·0	·47	—	—	—	—	—	—	—	133·10	31·30
20	500	19·69	13·0	·51	—	—	—	—	—	—	—	161·10	37·60

TABLE XVII

SPECIAL PIECES

(*Weight per piece in kilos*)

Nominal size	Bends		Parallel	Tee Piece	Cross Piece	Connectors		"Y" Piece	Branches		Running Trap	Drain Trap	Full "S" Trap
	45°	90°				Single socket	Double socket		45° Single	45° Double			
ins.	f.27	f.28	f.29	f.30	f.31	f.32	f.33	f.37	f.38	f.39	f.34	f.35	f.36
1	·13	·15	·20	·25	·3	—	·25	·35	·3	·5	·3	·50	·30
1¼	·17	·20	·25	·30	·4	—	·30	·45	·4	·6	·4	·60	·35
1½	·25	·30	·35	·40	·6	—	·35	·60	·5	·8	·5	·75	·45
2	·50	·60	·60	·80	1·0	·4	·50	1·00	1·0	1·3	1·0	1·70	1·00
2½	·60	·80	·80	1·00	1·5	·5	·65	1·30	1·2	1·7	1·3	2·00	1·20
3¼	·80	1·00	1·20	1·50	2·0	·6	·85	1·60	1·6	2·3	1·8	3·00	1·70
4	1·20	1·40	1·50	2·00	3·4	·8	1·00	2·40	2·4	3·2	3·2	4·50	3·00
5	2·00	2·30	2·50	2·70	4·0	1·0	1·50	3·30	3·6	4·7	4·8	6·50	4·70
6	2·40	2·70	3·70	3·90	6·0	1·2	1·80	4·00	4·8	6·2	6·5	9·00	6·00
7	3·20	3·60	5·20	5·50	7·5	1·6	2·30	5·50	7·0	8·0	9·0	11·00	9·00
8	3·60	4·50	6·20	6·50	9·0	2·0	2·70	7·00	8·4	11·0	11·0	14·00	11·00
10	5·50	7·00	10·00	12·00	18·0	4·5	5·50	11·00	15·0	18·0	—	—	—
12	7·00	8·50	13·00	15·00	25·0	6·0	7·00	16·00	20·0	30·0	—	—	—

NOTE.—A tolerance of approximately 10 per cent. is allowed on the weights listed in the above two Tables.

DIMENSIONS OF SOCKETS

OF "ITALIT" ASBESTOS-CEMENT LOW PRESSURE PIPES & SPECIALS

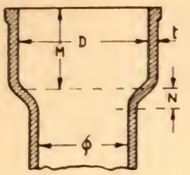


FIG. 36
SOCKET OF SPECIALS

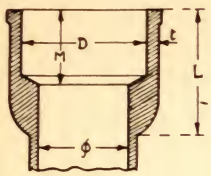


FIG. 37
APPLIED SOCKET

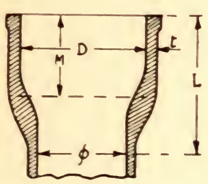


FIG. 38
MONOLITHIC SOCKET

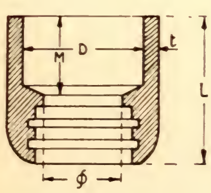


FIG. 39
TWO CHAMBERED SOCKET

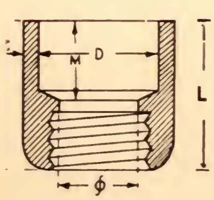


FIG. 40
SCREWED SOCKET

TABLE XVIII (sizes in inches)

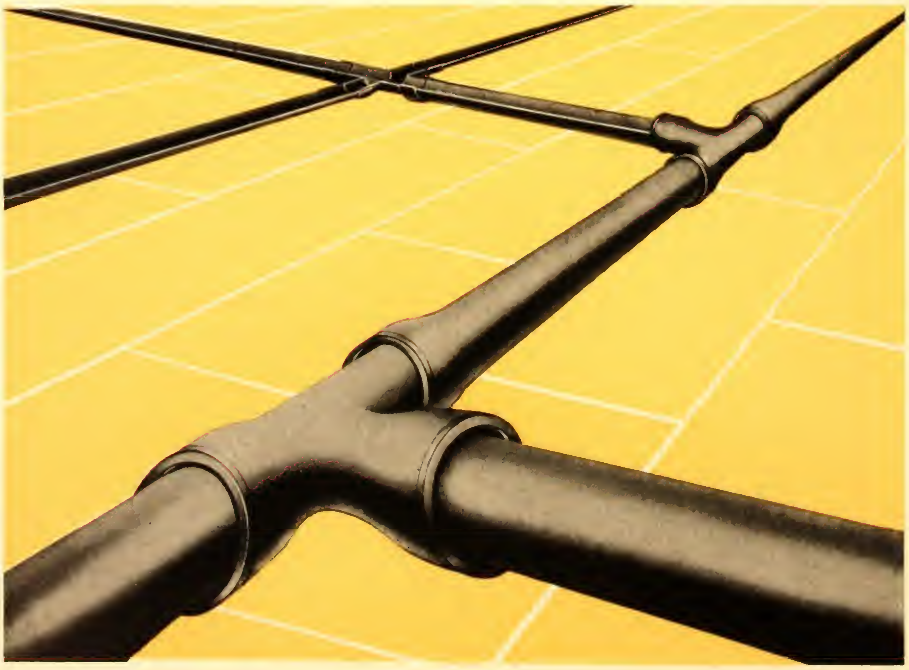
Nominal size of pipe ... ins.		1	1¼	1½	2	2½	3¼	4	5	6	7	8	10	12	14	16	18	20
Monolithic Socket of Pipes (Figure 38)	D	1·77	2·05	2·40	2·99	3·46	4·33	5·20	6·34	7·32	8·31	9·25	11·42	13·39	—	—	—	—
	M	1·57	1·57	1·97	2·96	2·56	2·56	2·56	2·56	3·15	3·15	3·15	3·15	3·15	—	—	—	—
	L	3·19	3·23	3·54	3·86	4·88	4·92	4·96	5·24	6·28	5·63	5·63	5·67	5·87	—	—	—	—
	t	·30	·30	·30	·30	·39	·39	·39	·47	·47	·47	·47	·51	·51	—	—	—	—
Socket of all Specials (Figure 36)	D	1·92	2·2	2·55	2·99	3·54	4·41	5·27	6·33	7·48	8·46	9·44	11·49	13·50	—	—	—	—
	M	1·57	1·57	1·97	1·97	2·76	2·76	2·76	2·76	3·15	3·15	3·15	3·15	3·15	—	—	—	—
	N	·55	·63	·67	·75	·90	1·1	1·18	1·18	1·18	1·18	1·18	1·34	1·57	—	—	—	—
	t	·16	·16	·18	·20	·24	·28	·32	·35	·35	·35	·35	·39	·39	—	—	—	—
Separate Sockets (Screwed or Two Chambered) (Figures 39–40)	D	1·77	2·05	2·40	2·99	3·46	4·33	5·20	6·34	7·32	8·31	9·29	11·42	13·39	15·43	17·64	—	—
	M	1·57	1·57	1·97	1·97	2·56	2·56	2·56	2·56	2·56	3·15	3·15	3·15	3·15	3·15	3·54	—	—
	L	3·07	3·07	3·46	3·54	4·33	4·33	4·72	4·72	4·72	5·12	5·12	5·12	5·12	5·12	5·51	—	—
	t_1	·30	·30	·30	·30	·39	·39	·39	·47	·47	·47	·47	·51	·51	·51	·51	—	—
Weight	kg.	·25	·35	·45	·50	·70	·90	1·30	1·50	1·70	2·20	3·00	3·60	5·00	6·50	8·50	—	—
Applied Socket (Figure 37)	D	1·77	2·05	2·40	2·99	3·46	4·33	5·20	6·34	7·32	8·31	9·25	11·42	13·39	15·59	17·64	19·61	21·65
	M	2·32	2·32	2·32	2·36	2·36	2·36	2·36	2·36	2·36	2·36	2·36	2·36	2·36	3·15	3·54	3·54	3·54
	L	3·35	3·35	3·27	3·94	3·94	3·94	3·94	3·94	3·94	4·33	4·33	4·33	4·33	5·11	5·51	5·51	5·9
	t	·30	·30	·30	·30	·39	·39	·39	·47	·47	·47	·47	·51	·51	·51	·51	·51	·55

TABLE XIX (sizes in mm.)

Nominal size of pipe ... ins.		1	1¼	1½	2	2½	3¼	4	5	6	7	8	10	12	14	16	18	20
Monolithic Socket (Figure 38)	D	45	52	61	76	88	110	132	161	186	211	236	290	340	—	—	—	—
	M	40	40	50	70	70	70	70	70	80	80	80	80	80	—	—	—	—
	L	81	82	90	98	124	125	126	133	134	143	143	144	149	—	—	—	—
	t	7·5	7·5	7·5	7·5	10	10	10	12	12	12	12	13	13	—	—	—	—
Socket of all Specials (Figure 36)	D	49	56	65	76	90	112	134	161	190	215	240	292	343	—	—	—	—
	M	40	40	50	50	70	70	70	70	80	80	80	80	80	—	—	—	—
	N	14	16	17	19	23	28	30	30	30	30	30	34	40	—	—	—	—
	t	4	4	4·5	5	6	7	8	9	9	9	9	10	10	—	—	—	—
Separate Sockets (Figures 39–40)	D	45	52	61	76	88	110	132	161	186	211	236	290	340	392	448	—	—
	M	40	40	50	50	70	70	70	70	70	80	80	80	80	80	90	—	—
	L	78	78	88	90	110	110	120	120	120	130	130	130	130	130	140	—	—
	t	7·5	7·5	7·5	7·5	10	10	10	12	12	12	12	13	13	13	13	—	—
Weight	kg.	·25	·35	·45	·50	·70	·90	1·3	1·5	1·7	2·2	3·0	3·6	5·0	6·5	8·5	—	—
Applied Socket (Figure 37)	D	45	52	61	76	88	110	132	161	186	211	236	290	340	396	448	498	550
	M	59	59	59	60	60	60	60	60	60	60	60	60	60	80	90	90	90
	L	85	85	85	100	100	100	100	100	100	110	110	110	110	130	140	140	150
	t	7·5	7·5	7·5	7·5	10	10	10	12	12	12	12	13	13	13	13	13	14

ASBESTOS-CEMENT

IRRIGATION PIPES



"ITALIT" ASBESTOS-CEMENT IRRIGATION PIPES

THESE pipes are manufactured by exactly the same process as Pressure Pipes, therefore possessing all the advantages mentioned in previous chapters (see pages 21-25).

They are made with monolithic sockets as described on page 31. The joint is completed by means of a rubber ring and possessing a good degree of flexibility, allows for deviations on the land surface.

" ITALIT " Irrigation pipes are made in diameters from 2 ins. to 12 ins. nominal, in lengths of 1, 2 and 3 metres (See table opposite). They are tested at 102 feet head (3kg/cm^2) hydraulic pressure, recommended for working pressures up to one half their Test pressure. Their average tensile strength equals 1700 lbs./sq. in. (120 kg/cm.^{2}).

The following asbestos-cement **bends and special pieces** are available for use with Irrigation Pipes :

45° Bend	90° Bend
Tee Piece	Cross Piece

Tees and Cross Pieces can be supplied with branches of smaller diameter.

OPEN CHANNELS for conveying the water from the main pipes into irrigation streams along the fields are also available. They are of half round section with one end provided with socket for jointing. Open channels are made in diameters from 5 ins. to 12 ins. nominal, 4, 6 and 8 ft. long.

Bends, Tees, and Cross-Pieces, of half round section are offered for use with these. They are provided with internal grooves into which asbestos-cement sluice gates can be fitted to regulate the flow of water.

TABLE XX

DIMENSIONS & WEIGHTS OF "ITALIT" ASBESTOS-CEMENT

IRRIGATION PIPES AND SPECIALS

Complete with Monolithic Socket

Nominal size	Actual internal diameter		Thickness		Weight in kilos per pipe inclusive of socket			Weight in kilos per special piece				Nominal size
					Length 1 m. (3·28 ft.)	Length 2 m. (6·56 ft.)	Length 3 m. (9·84 ft.)	45° Bend	90° Bend	Tee piece	Cross piece	
ins.	mm.	ins.	mm.	ins.								ins.
2	50	1·97	5	·20	2·1	3·8	5·5	·84	·87	1·4	1·9	2
2½	60	2·36	6	·24	3·1	5·5	8·0	1·17	1·22	1·9	2·7	2½
3¼	80	3·15	7	·28	4·7	8·5	12·4	1·60	1·70	2·6	3·7	3¼
4	100	3·94	8	·32	5·9	10·6	15·3	2·45	2·70	4·1	5·5	4
5	125	4·92	9	·35	8·5	15·4	22·3	3·50	3·60	5·5	7·1	5
6	150	5·91	9	·35	10·4	18·8	27·2	4·25	5·00	7·2	9·4	6
7	175	6·89	9	·35	11·5	20·5	29·5	5·13	5·94	8·7	11·1	7
8	200	7·87	9	·35	14·5	25·5	36·9	6·12	7·10	10·2	13·3	8
10	250	9·84	10	·39	18·6	33·2	47·8	8·63	10·60	14·5	18·4	10
12	300	11·81	10	·39	23·4	42·2	61·0	11·00	13·60	19·6	23·0	12

NOTE.—A tolerance of approximately 10 per cent. is allowed on these weights.

FIG. 41—IRRIGATION SCHEME NEAR FERRARA EMPLOYING "ITALIT" IRRIGATION PIPES. THE PHOTOGRAPH SHOWS THAT THE PIPES CAN EASILY BE DRILLED, IF REQUIRED, FOR FLOODING THE LAND. THE ARROW SHOWS THE FLEXIBILITY OF THE JOINTS.

INSTRUCTIONS FOR

LAYING, JOINTING AND TESTING

ITALIT

ASBESTOS-CEMENT

PIPES

LAYING, JOINTING AND TESTING INSTRUCTIONS FOR "ITALIT" PIPES

"ITALIT" pipes are of light weight, which facilitates their handling. They do not require any greater care than is normal with other kinds of pipes. Observance of the following rules and suggestions for laying the pipes is of utmost importance, as the lasting efficiency of a pipe-line depends equally upon the care expended in laying operations as upon the quality of the materials.

General Layout

Although a dead-straight layout is theoretically ideal for a pipe-line, it seldom occurs in practice, especially in mountainous or rolling country, but every effort should be made to follow as straight a course as possible.

In the matter of altitude it will usually be difficult to keep a constant gradient on account of the necessity of approximately following the lie of the land, also of attaining and connecting certain piezometric heights and levels that have been established by calculation in the plans. Therefore, at times, the pipe line will be subjected to bends and deviations, both in the vertical and horizontal planes. These can be easily overcome, up to a certain degree of angularity, by the adoption of the Simplex or Gibault Joint.

Both these joints are flexible and permit angular deviations, thereby allowing movements of settling ground and traffic vibrations without damage being caused to the pipe-line.

They also permit the negotiation of long radius curves without need of special bends.

Assuming an angular deviation of 6° at each joint, the following radii are obtained:

TABLE XXI

Pipe length	*Radius*		
m.	*m.*	*ft.*	*ins.*
1	9·5	31	2
2	19·0	62	4
3	28·5	93	6
4	38·0	124	8
5	47·5	155	10

When very pronounced deviations are required it is necessary to adopt asbestos-cement or cast iron pressure bends.

FIG. 42.—TRENCH EXCAVATED IN ROCK FOR DUAL 28 IN. (700 MM.) DIA. "ITALIT" PIPE-LINE WITH SIMPLEX JOINT, PART OF THE ISTRIAN ACQUEDUCT NEAR TRIESTE

Trenching

When the bottom of the trench is used as the bed of the pipe-line, it should be levelled with care and conform to the established grade. (Figure 42).

FIG. 43.—JOINTING 32 IN. (800 MM.) DIA. PIPES WITH SIMPLEX JOINTS. NOTE LATERAL NICHES DUG IN TRENCH WALLS TO FACILITATE WORKING.

Any prominent pieces of rock or other hard substances should be removed. Filling the bottom of the trench to the level of a high spot is not recommended as it is not possible to ram the refilled material hard enough and the high spots will give trouble, after the soil has settled. In such a case the pipe would not lie with its entire length resting on the bed of the trench, but remain poised on a number of high spots, thus being subjected to unnecessary strains by the loads from above ; under such conditions, a sudden rise in hydraulic pressure would produce an equally sudden increase in the vertical reactions at points of contact, and sheering stresses would occur that might result in the transverse cracking of the pipe.

When the particular nature of the land requires it, a certain amount of concrete is laid in order to provide an adequate bed for the pipes. This method is advisable in porous sub-soil or in the case of rocky strata, to obtain an even surfaced trench bed. The same effect may sometimes be achieved, and more economically, by using plain earth or sand for the bed of the trench. Under each joint, it is necessary to make a suitable excavation in the bottom of the trench, so that the lower portion of the pipe may rest effectively along its entire length. This excavation should

FIG. 44.—"ITALIT" PIPES CLASS B 18 IN. (450 MM.) DIA. READY FOR LAYING.

be dug after the bottom of the trench has been levelled and is ready to receive the pipes, and be of sufficient clearance for allowing the workmen to operate in making the joint. The width of the trench should be at least 1 ft. wider than the diameter of the pipe, in order to allow the workmen to operate without discomfort.

LAYING

If the pipes and joints are laid along the top of the trench leaving their ends clear of all loose earth or material, it will facilitate and speed laying.

Before lowering the pipes into the trench they should be carefully examined to find out whether any damage has been done during transit, loading or unloading, especially the butt ends which are their most vulnerable part. When it is evident, from outward signs, that the pipe has received a damaging blow, the surface around that spot should be carefully examined, if the blow has been a hard one, there may be cracks which are not visible to the eye ; in the case of doubt as to their existence, it is advisable to saw off the damaged portion of the pipe, which will then be as good as new.

FIG. 46.—LAYING 32 IN. (400 MM.) DIA CLASS B PIPES FOR THE SCALENGHE ACQUEDUCT. SIMPLEX JOINTS WERE USED.

FIG. 45.—LOWERING 16 IN. (400 MM.) DIA. PIPES INTO THE TRENCH.

When a pipe has been examined and found to be in good order it is lowered into the trench. This is usually done by hand for small diameter pipes.

In the case of larger pipes the simple method of lowering by rope can be done, with the rope encircling the pipe, and one end being anchored to the ground. For very large pipes a derrick will probably be necessary.

When the pipe is laid safely at the bottom of the trench, and before coupling, the components of each joint should be carefully examined in order to detect possible flaws.

Where preferred, sections of pipes can be assembled above the trench and lowered as a unit, a good foundation having previously been made in advance for their reception.

JOINTING

Before making the joints the pipe ends should be cleaned in order to ensure a good seating for the rubber rings. These should be placed on the pipes clean and free from twist.

Mounting of the Simplex Joint

(1) To ensure the correct positioning of the sleeve, two marks should be drawn on each pipe at a distance from their ends equal to half the length of the sleeve.

(2) Slip the sleeve, the smaller bore first, upon pipe A, (which should be anchored) at a distance from the pipe end at least one inch greater than its length.

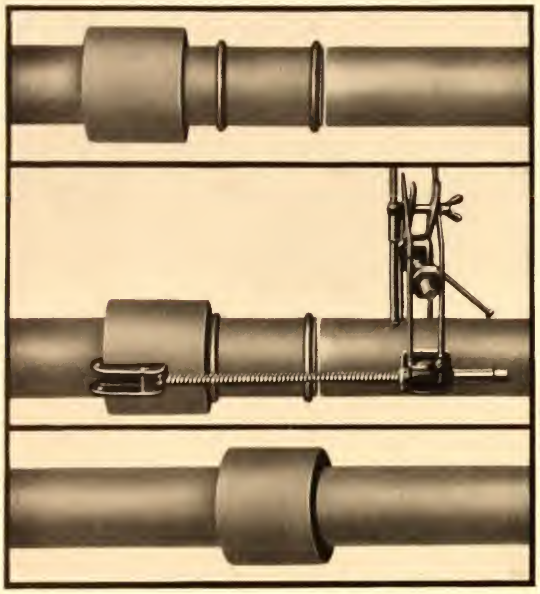


FIG. 47.—ASSEMBLING SIMPLEX JOINT USING JOINT MOUNTING TOOL

(3) Place one rubber ring on the same pipe at the following distances from the pipe end:

6 ins. for pipes up to 2 ins. diameter
$6\frac{3}{4}$ ins. for pipes 2 to 10 ins. diameter
$7\frac{1}{2}$ ins. for pipes 12 to 20 ins. diameter
8·1 ins. for pipes 24 to 40 ins. diameter

A templet to enable the worker to gauge the above distances, can be easily made.

(4) The last ring should then be placed at the end of pipe A for pipes larger than 2 ins.; at the end of pipe B for the smaller pipes.

(5) Draw the second pipe B to pipe A and align them for jointing, taking care in the case of pipes 12 to 20 ins., to keep the pipe without sleeve, one-twelfth of an inch higher than the other one, in order to facilitate the following operation.

(6) For pipes 24 to 40 ins. a special levelling apparatus is placed inside the pipes at the joint in order to keep the abbutting ends in alignment and at their correct distance apart.

(7) Keeping pipe B anchored, pull the sleeve over the rubber rings, compressing and rolling them along, until the sleeve is centered on the ends of the pipes, as will be shown by the two marks previously made. For pipes up to 2 ins., this can be done by hand; for larger pipes a

FIG. 48.—ASSEMBLING SIMPLEX JOINT BY MEANS OF LEVERS

joint mounting tool is clamped on pipe B with the pulling screws expanded so that the hooks engage behind the sleeve on pipe A. By rotating the screws, the sleeve is drawn forward into its correct position.

With pipes 24 to 40 ins. diameter the hooks, which are supported by transverse chains, should engage the sleeve well below the level of the axis. During the pulling operation the movement of the sleeve should be assisted with a mallet and two small levers to prevent binding.

(8) The levelling apparatus, placed in the interior of large diameter pipes, should now be removed.

In the case of pipes up to 20 ins., in which this tool is not used, the free pipe should be drawn away from the other for $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in order to allow for joint flexibility.

(9) As the last operation, one side of the sleeve, i.e. the end of the sleeve which was drawn over the rubber rings, should be grouted with cement mortar, thus

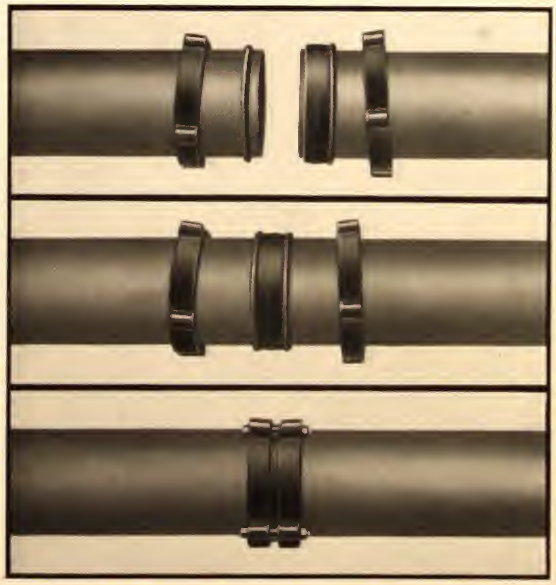


FIG. 49.—ASSEMBLY OF GIBAULT JOINT

FIG. 50.—ANCHORAGE OF "ITALIT" PIPE-LINE AT BENDS BY CONCRETE BLOCKS LEAVING JOINTS FREE

preventing any displacement of the sleeve and ensuring protection of the rubber ring.

With sloping pipe-lines, it is necessary to mount the sleeve with the open end up the slope, in order to facilitate the application of the mortar.

Mounting of the Gibault Joint

Slip one of the joint flanges, followed by one rubber ring, on the end of each pipe and place the collar over the end of one of them.

Draw the two butt ends of the pipes together, insert the bolts and tighten them evenly each nut in turn. During this operation the rubber rings are compressed against the sleeve, thus making the joint tight.

Anchorage of Pipe-line

Where the pipe-line follows a steep gradient, retaining blocks of concrete or masonry should be constructed in the vicinity of couplings; in the case

of large diameter pipes there should be one or two per pipe.

These blocks should also be provided at bends, tees, dead ends, etc., which are subjected to thrusts.

The retaining blocks should be founded on solid ground, and envelop the fittings leaving the couplings free for inspection.

FIG. 52.—TESTING A PIPE-LINE. NOTE THE PARTIAL FILLING OF THE TRENCH LEAVING THE JOINTS FREE FOR INSPECTION

Testing of Pipe-Line

Where a section of pipe-line has been finished, for a distance of say 300 yds. to 500 yds. at the utmost, it is always advisable to carry out a partial test in order to detect flaws, if any, in the line and correct them before filling in.

Before doing this it is necessary to secure the pipes against displacement during the test, by partially filling the trench with earth free from large stones, slightly rammed around the pipes to a length of 2-3 yds. and to the full width of the trench, care being taken to leave the joints exposed and clean for inspection.

To seal the open end of the section under test, a blank end cap should be employed.

In order to neutralize the longitudinal thrust on the cap during the pressure test, some form of buttress must be provided.

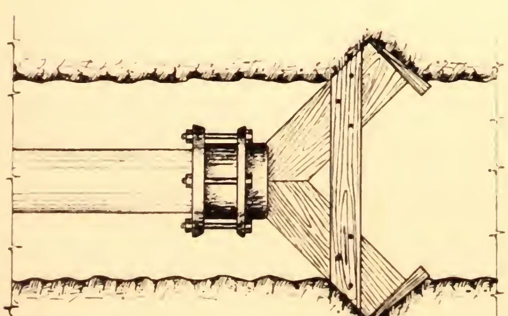


FIG. 51.—METHOD OF BUTTRESSING AN END CAP DURING PRESSURE TESTS

The length under test will then be slowly filled with water from the lowest point, in order to ensure the complete elimination of the air through the upper taps and sluice valves, which shall have been previously left open for the necessary time.

Afterwards, it is advisable to leave the length of main under test, full of water at atmospheric pressure for three consecutive days.

The Working Pressure will then be gradually reached by means of a hand pump applied to the lowest point of the main. Such a pressure will be maintained for the time necessary to inspect the pipe line along both sides and to discern possible faults due to such causes as broken pipes and joints, leakages from special pieces, porosity of cast iron specials, faulty mounting, etc. In the case of any of the above faults being discovered, the pressure will be withdrawn and the necessary repairs executed, after which the part of main

under consideration will be ready for the final test.

This consists in first reaching, by means of the hand pump, the Working Pressure and finally the Operational Test Pressure having care, during this operation, to keep the pressure stationary for one minute after every increase in pressure of 14 lbs. per sq. in. (1 kg./cm²). The Operational Test Pressure, to be maintained for at least six hours during the final test, should have a value between $1\frac{1}{4}$ and $1\frac{1}{2}$ times the Working Pressure.

The test is final when the pressure gauge does not show any drop in pressure during the specified testing time. In regard to constancy of pressure during the test it is as well to remember that all asbestos-cement pipes are subject to the peculiar phenomenon known as "absorption under pressure" (up to 7 per cent. of their weight). If the pipes are not yet saturated, then the gauge may show a slight pressure drop, even though there is no leakage. It should also be remembered that there is a type of damp spot which may appear upon the pipe, which is due to water creeping under the first layer of cement; this happens for a length of some 2 to 3 ins. beginning at the coupling and it is not a sign of leakage. These spots usually disappear after a few days.

Final Filling

After the test has been completed the trench may be filled back in the usual manner, care being taken against throwing in large stones until a sufficient protective earth covering has been placed over the pipes.

FIG. 53.—ASSEMBLY OF THE SIMPLEX JOINT BY MEANS OF THE JOINT MOUNTING TOOL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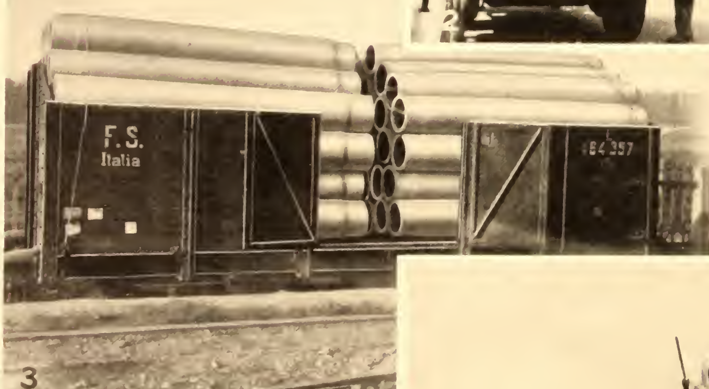
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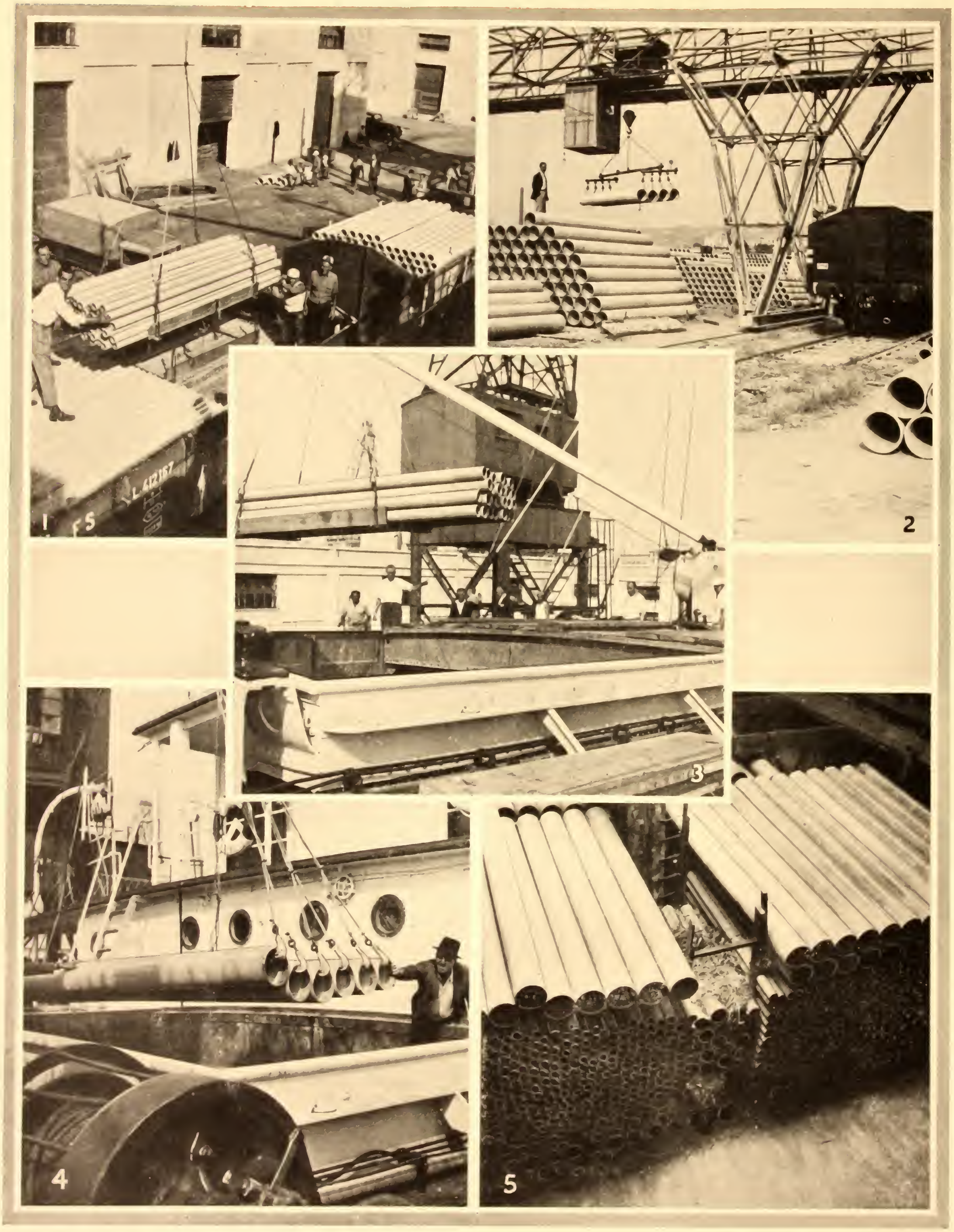
TRANSPORT—BY SEA

1, 2 AND 3. GENOA DOCKS—LOADING AND STOWING 40 IN. (1000 MM.) "ITALIT" PIPES FOR GREECE
4. MEDIUM SIZED PIPES SWUNG INBOARD 5. VARIOUS DIA. "ITALIT" PIPES NESTED IN BARGE FOR CANAL TRANSPORT



1. LOADING OF SMALL DIA. PIPES BY MEANS OF SPECIAL PLATFORM
2. LOADING ON TRUCKS BY CRANE EMPLOYING END HOOKS
3. LOWERING PLATFORM INTO HOLD
4. MEDIUM DIA. PIPES BEING LOWERED INTO HOLD USING END HOOKS
5. STOWAGE

TABLE XXII

METRIC EQUIVALENTS

Based on

1 in. = 25·4 mm. ; 1 litre = 1000·028 cm.^{3}; 1 lb. = 0.45359243 kg.;
1 imp. gallon = 277·42 cub. in.; 1 U.S. gallon = 231·0 cub. in.

				Reciprocal
1 millimetre	=	0·03937	inch	25·4
1 centimetre	=	0·3937	inch	2·54
1 metre	=	39·3701	inches	0·0254
	=	3·28084	feet	0·3048
	=	1·09361	yard	0·9144
1 kilometre	=	0·62137	mile	1·60934
1 sq. centimetre	=	0·155	sq. inch	6·4516
1 sq. metre	=	10·764	sq. feet	0·0929
	=	1·196	sq. yard	0·8361
1 hectare	=	2·471	acre	0·40469
1 cubic centimetre	=	0·061024	cu. inch	16·3871
1 cubic metre	=	35·3147	cu. feet	0·028317
	=	1·30795	cu. yard	0·76455
	=	219·969	imp. gallons	0·004546
	=	264·17	U.S. gallons	0·0037854
1 litre	=	61·02571	cu. inches	0·0163865
	=	0·0353156	cu. foot	28·3161
	=	0·219975	imp. gallon	4·54596
1 gram	=	15·4324	grains	0·0648
1 kilogram	=	2·20462	pounds	0·453592
	=	35·274	ounces (av.)	0·02835
1 metric ton (1,000 kg.)	=	0·98421	ton	1·01605
1 kg./sq. cm.	=	14·2233	lb./sq. in.	0·070307
	=	32·8093	ft. hd. of water	0·030479
1 Standard Atmosphere	=	14·696	lb./sq. in.	0·068046
	=	1·0332	kg./cm.^{2}	0·96784
	=	33·9	ft. hd. of water	0·0295
1 kg./sq. millimetre	=	0·63497	ton/sq. in.	1·57488
1 kg./sq. metre	=	0·204816	lb./sq. ft.	4·88243
1 kg./cu. metre	=	0·062428	lb./cu. ft.	16·01845
1 kg./litre	=	10·0221	lb./gallon	0·09978
	=	62·426	lb./cu. ft.	0·01602
1 kilogrammetre	=	7·233	ft. pound	0·13825
1 watt	=	44·0	ft. lb./minute	0·02273
1 kilowatt	=	1·341	H.P.	0·7457

NOTE.—Whilst every care has been taken in compiling this table, we cannot assume responsibility for its accuracy.

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